

10/594798

Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/US05/011291

International filing date: 01 April 2005 (01.04.2005)

Document type: Certified copy of priority document

Document details: Country/Office: US
Number: 60/558,119
Filing date: 01 April 2004 (01.04.2004)

Date of receipt at the International Bureau: 12 May 2005 (12.05.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)



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APPLICATION NUMBER: *60/558,119*

FILING DATE: *April 01, 2004*

RELATED PCT APPLICATION NUMBER: *PCT/US05/11291*



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13281 U.S. PTO

PTO/SB/16 (08-03)

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. <<TEXT>>

INVENTOR(S)					
Given Name (first and middle (if any))	Family Name or Surname	Residence (City and either State or Foreign Country)			
Barry W. Byron K.	Townsend Claudio	Bakersfield, California Bakersfield, California			
<input type="checkbox"/> Additional inventors are being named on the <<TEXT>> separately numbered sheets attached hereto					
TITLE OF THE INVENTION (500 characters max)					
LOWER EXTREMITY PROSTHESIS REPLICATING FUNCTION OF HUMAN MUSCULATURE					
Direct all correspondence to:		CORRESPONDENCE ADDRESS			
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ENCLOSED APPLICATION PARTS (check all that apply)					
<input checked="" type="checkbox"/> Specification Number of Pages		30		<input type="checkbox"/> CD(s), Number	
<input checked="" type="checkbox"/> Drawing(s) Number of Sheets		41		<input checked="" type="checkbox"/> Other (specify) Credit Card Payment Form	
<input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76					
METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT					
<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.					
<input type="checkbox"/> A check or money order is enclosed to cover the filing fees					
<input type="checkbox"/> The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 01-2135					
<input checked="" type="checkbox"/> Payment by credit card. Form PTO-2038 is attached.					
The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.					
<input checked="" type="checkbox"/> No					
<input type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are:					

[Page 1 of 1]

Date 04/01/04

Respectfully submitted,

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REGISTRATION NO. **28,577**

(if appropriate)

Docket Number: **183.437311.00****USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT**

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Artificial Muscle Form and Function

- I. Design concept intro = problem 14% (long) -26% (short). Solution needed...windlass, human and prosthetic comparison.

a. Energy

i. PE

ii. EE

iii. $KE = K P$

iv. $K Power = Force$

b. Foot, ankle, calf, shank, ~~posterior artificial muscle~~

c. Artificial muscle = *VISCOELASTIC PASSIVE DEVICE*

d. Increased PE $= KE = \frac{1}{2} m v^2$

i. CAM post calf

ii. Foot shell

iii. Windlass

II. Artificial muscle = *VISCOELASTIC PASSIVE DEVICE*

a. Max tension, max unloading.

i. Mass, length, width, cross-sectional area

ii.

b. Form and function, monolithic and integral

i. Strap solid

ii. Fusiform

iii. Bi-pinnate

iv. Multi-pinnate

v. Combination of design

1. strap to muscle

c. Function

III. Cams, Pads, Bladders

a. Cams

i. Worm gear

ii. Bolt adjustment

iii. Syllinoid

b. Pads

i. Posterior calf

ii. Longitudinal arch

iii. Bladders

1. Calf

IV. Foot Shell

V. Claims

Background and Field of Invention

HYDRAULIC + A CONTRASTING DEVICE
Our invention is a device that replicates the function of human musculature. A device that adds potential energy to a prosthetic system which results in an increase in the prosthetic systems kinetic power generation potential. Wherein, the increase in kinetic power generation can be manipulated by the user to facilitate functional outcomes as required by the users activities.

Provisional Patent

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I. Design Concept – Background, Intro

The prosthesis as shown in our high performance foot patent # US 6,562,075 as represented by figures ~~1~~, 1, 2, ~~3~~, and ~~4~~ have been pathokinesiology (~~GAIT~~ GAIT) tested (3D motion analyzed) on two unilateral transtibial amputees at Stanford

University and the University of Southern California (USC). The test results indicate see figures ~~3~~ 3 ~~4~~ (jack KP) that the prosthesis does not produce equal amounts of ankle joint sagittal plane ^{kinetic} power as the unaffected side ~~limb~~ ^{compared to} creating inequalities in gait.

^{mis} Figure 3 (jack KP) shows that a 14% gap exists between the prosthetic ankle joint sagittal plane kinetic power and his unaffected "normal" side. Fig 4 (average KP) indicates that the average of two subjects prosthetic side sagittal plane ankle joint kinetic power wherein one subject had an 8" inch long calf shank fig 3 and the other test subject had a 4" long calf shank as shown in figure 3 ^{mis figure} 3 indicates that a 26% gap exists between "normal" unaffected and affected (prosthetic side) ankle joint sagittal plane kinetic power. This sagittal plane ankle joint kinetic power generation has been identified as the propulsive force needed to propel the trailing limb and body forward for the next step.

The scientific literature suggests that even though all prior art prosthetic feet have varied mechanical designs they all function (in creating sagittal plane ankle joint power) about the same. For example, US patent # 5,066,305 (Seattle Lite Foot) and Safe Foot US patent # 5,066,305 create approximately 25% of "normal" ankle joint sagittal plane kinetic power. This represents a ~~76%~~ 75% gap between the affected and unaffected sides. ~~The problem of generating "normal" human ankle joint sagittal plane kinetic power with a prosthetic foot, ankle, and calf...?~~

Van Phillips US patent # 4,154,913 shows a prior art prosthetic foot, ankle, and calf

wherein the calf and ankle are monolithically formed. This patent represents one of the first attempts to include an elastic energy storage system at the calf shank level. This

particular prosthetic design configuration has been re-invented by patents

5,776,205 / US 6,241,77601

US 6,602,295 B1

5,593,457

6,076,313 / US 6,280,479

5,809,944

5,486,205

5,944,760 / US PUBLICATION # US 2003/0191541A

5,191,932

US PUBLICATION # US 2003/0093158 A1

" " US 2003/0120754 A1

" " US 2002/007706 A1

The ankle joints sagittal plane kinetic power generation potential in these designs

is significantly and deficiently affected. Figure 5 (Jacks TPA and Flex) shows a

unilateral transtibial amputee who wore in separate gait trials a Van Phillips patent #

5,154,185 foot and our foot figure 1. The difference in prosthetic ankle joint sagittal

plane kinetic power generation indicates that our prosthetic design generates

approximately 143% more power.

The 14% gap in ankle joint sagittal plane kinetic power generation that exists

between our prosthetic foot system and the human foot and ankle system can be

bridged by adding a posterior ~~can~~ ^{VISCOELASTIC FOR A LEAPSPRING DEVICE} device that adds potential and elastic energy storage capacity to our prosthetic system.

Design Concept

Through the proper application of mechanical design a prosthetic structure, in this case a foot, ankle, calf, and posterior ~~artificial muscle~~ ^{VISCOELASTIC FOR LEAPSPRING DEVICES} design, has been created, which for the first time efficiently transforms potential elastic stored energy into kinetic energy and measurably improves the terminal stance phase propulsive force, at the

ankle, allowing for normalized advancement of the trailing limb and forward movement during amputee gait.

Design Theory

The foundation for the Phase I prototype designs (P1 and P2 - both of which incorporate a resilient longitudinal foot keel, rigid ankle coupler, resilient anterior facing convexly curved parabolic calf shank, and posterior ^{SHANK VISCO ELASTIC} ~~calf artificial muscle~~ device) were the mechanical structures of the human foot, ankle, and calf and their respective responses to ground reaction force throughout the stance phase of gait. By better understanding the biomechanical processes in the human foot, ankle, and calf we believe that we can create a lower extremity prosthesis, which is purely mechanical, that will be capable of replicating normal human function.

Over the past 5 years our Phase I prototypes have evolved to achieve an accurate representation of the known biomechanical processes, as they occur in human gait.

The primary focus of the design is to use resilient structures that have the capacity to store elastic energy which can be transformed into kinetic energy. This mechanical energy concept was taken one step further by creating a posterior ~~calf~~ ^{SHANK} ~~artificial muscle~~ ^{VISCO ELASTIC FOR WEARABLES} device which has the capability of storing its own potential energy, wherein the potential energy is created by the work required to load the ^{device} ~~muscle~~ with energy. A simple illustration, conceptually, of potential and kinetic energy can be explained by the stretch and release of a rubber band. When the rubber band is stretched it stores potential energy via its elasticity and when the rubber band is released the elastic stored energy is transformed into kinetic energy or the contraction

ELASTIC ENERGY STORAGE CAPACITY

of the rubber band. This same principle applies to the ^{capacity} of the resilient longitudinal foot keel and parabolic ~~calf~~ shank. In the stance phase of gait mechanical energy is created by the multi-segment system. This mechanical energy through the gait cycle creates potential energy by "loading" the ^{Resilient} elastic ~~calf~~ shank and foot keel. The stored elastic ~~potential~~ energy is released/transformed via the mechanical structures of the Phase I prototype into kinetic energy which ^{is transformed to kinetic power} creates a propulsive force. Moreover, during gait, the body's center of gravity rises and falls creating potential and kinetic energy, respectively. These alternating energy events contribute to the efficiency of human locomotion, through the cyclic nature of energy absorption and generation, and enhance the loading properties of the elastic prosthetic foot.

The second major design theory incorporates a variable geometric mechanical design concept, wherein, through the orchestration of one radius next to another, wherein, the radii orientation are manipulated in the sagittal, frontal and transverse planes. This radii orchestration was further developed by arranging the radii to respond to a single ground reaction force by compressing and/or expanding. This compression and/or expansion of the radius relates directly to the angular velocity of the resilient structure going down or up respectively. Further development of this radii concept includes that the angular velocity potential is a function of the radius size and is a function of the distance from a point of rotation. A larger radius has greater angular velocity potential. → put in New Analysis → MULTI SEGMENT → ATTACHMENT (A)

Our current prosthetic system which includes a resilient foot, ~~ankle~~, and ~~calf~~ shank needs a boost of potential energy. Herein, lies our patent. A posterior and/or dorsal device and/or devices that not only adds potential energy but increases the

elastic energy storage capacity of the whole system. Wherein, each separate component, i.e. the longitudinal foot keel ~~and~~ shank posterior or dorsal device contributes a percentage to the total kinetic power generation value. (Our invention is to replicate the function of the human posterior calf musculature and the windlass action of the foot. Campbell Childs, US Patent #, achieved this foot windlass effect, however, our windlass design is more simplistic and effective with increased elastic energy storage capacity. ~~For I don't know if a patent subcategory exists on this subject. I also don't know of a prior art invention that incorporates the multitude of designs embodied in this provisional patent.)~~

The posterior ^{shank} ~~and~~ device could be a ^{single} ~~simple~~ leaf spring figure 6 with rigid and/or (elastic/resilient) strap. Or it could be an elastic artificial muscle representation, Figure 8+9. The artificial ^{VISCOELASTIC DEVICE} ~~muscle~~ could include a simple solid elastic strap (figure) 10 and/or multiple layers of straps. However, its form characteristics dictating specific motion characteristics. The ^{VISCOELASTIC DEVICE} ~~artificial muscle~~ further including a device that adds potential energy by pre-stretching and/or pre-loading the artificial muscle with potential energy. This ^{shank} ~~posterior~~ device #1 could be a pad, figure 11, and/or pads, figure 12, of different thicknesses, or it could be an air or hydraulic bladder, figure 13, or it could be a cam, figure 14, wherein, the user of the prosthesis manipulates the device #1 to increase and/or decrease the amount of potential energy added to the prosthetic system. Our prosthetic foot shell incorporates an elastic strap system that originates in the posterior plantar and inserts in the anterior plantar regions of a foot shell. ^{FIG 15} This elastic plantar foot system is not limited to being part of a foot shell system. It can be attached to the posterior and anterior ends of our longitudinal foot keel. ^{FIG 16 + 17} This elastic windlass system will increase the

elastic energy storage capacity of our foot keel system which when added to our prosthetic system will increase our elastic energy storage capacity. This elastic energy will be transformed into ^{increased} kinetic power.

Our elastic windlass foot system can be manipulated by the user to increase and/or decrease the amount of potential energy. This manipulation is achieved by a longitudinal arch pad system of various thicknesses and forms. ^{FIG 18} Each form/shape dictating a pre-determined stretch on the windlass system. In use the user can change the longitudinal pad to a thicker, thinner, wider, and/or narrower form, wherein a thicker longitudinal arch pad increases the length by stretching/preloading the windlass elastic material.

The need exists for device #1 and the windlass system because as the users activity level increases the prosthetic system should be able to be manipulated by the user to increase and/or decrease the kinetic power generation. This will allow our prosthesis to be utilized by the amputee for a wide variety of activities including walking, running, and jumping.

II. Artificial Muscle Section

Human muscles exhibits specific form and function characteristics. For example, a muscle can be fusiform and/or multi-pinnate formed each dictating different functional motion outcomes. A muscles mass as represented by a cross sectional area times length dictates its power potential. A larger muscle mass will create an increase in power potential. Two muscles of equal mass that are either ^{HAVE} long and narrower cross-section, figure ^{FIG 10A} ~~10A~~ ^{OR} ~~10B ^{FIG 10B} short and larger cross sectional areas create different motion outcomes. ^{FIG 19A} (19A). For example, a long and narrow cross sectional area muscle has~~

These FORM FUNCTION CHARACTERISTICS CAN BE SIMULATED WITH A VISCO ELASTIC PROSTHESIS.

FIG 19A

increase range of motion potential as compared to a short large cross sectional muscle. *FIG 19B*

A short and large cross sectional muscle of the same mass creates greater tension values in a shorter time frame. However, a long narrow muscle has greater unloading potential. In human walking the posterior calf muscle group in response to ^A ground reaction force loads eccentrically and an eccentrically contracting muscle has increased tension capabilities. Therefore a short wider cross sectional area muscle will replicate this function better than a long narrow muscle of the same mass. Different muscle configurations can be layered one on top of another creating many different motion outcomes. Each motion outcome potential having range of motion tension, unloading and timing characteristics.

move this sentence
VISCOELASTIC + RESILIENT STRUCTURE
(Our patent creates a prosthetic artificial muscle based on these simple biomechanical functions) *VISCOELASTIC + RESILIENT + ACTUATOR DEVICES*
Our artificial muscles are generally monolithically formed out of an elastic material such as rubber, however, anybody skilled in the art would know that elastic materials other than rubber could be utilized and that varying densities and durometers could be employed in the manufacture of *VISCOELASTIC DEVICES* *VISCOELASTIC DEVICES* our muscles. Our muscles could also be a biomechanical elastic structure incorporating resilin at the top end of the elastic spring efficiency scale. A hybrid of biological and mechanical forms. *VISCOELASTIC DEVICES* Our muscles can be integrally formed. Wherein, a material with different and/or the same elastic rating can be attached to the terminal ends wherein different mechanical forms are fastened together. *VISCOELASTIC DEVICES* Each artificial muscle having two terminal ends usually a proximal and distal orientation, however, as in the human they could be oriented medial to lateral and/or anterior to posterior or any combination thereof.

VISCOELASTIC DEVICES

Our ~~muscles~~ *VISCOELASTIC* can be manufactured by injection molding, machining or any combination thereof. Our ~~muscle~~ *VISCOELASTIC* forms can be a simple elastic strap *FIG 10 A* where in the cross sectional

area and length can be varied to achieve different functional motion outcomes. The

length can be varied to achieve different functional motion outcomes. The length to

cross sectional area of the muscle dictating specific elastic storage capacity, max

tension, max unloading and power potential. Our ~~muscles~~ *VISCOELASTIC DEVICES* can be solid, fusiform, bi-

pinnate and/or multi-pinnate formed with each ~~muscle~~ *VISCOELASTIC DEVICES* configuration dictating specific

motion outcomes. Our ~~muscles~~ *VISCOELASTIC DEVICES* can be single and/or multilayered. Our ~~muscles~~ *VISCOELASTIC DEVICES* can be

a combination of ~~muscle~~ *VISCOELASTIC* and/or ~~strap~~ *NON ELASTIC* or any combination thereof. Our ~~muscles~~ *VISCOELASTIC* elastic

energy storage capacity being derived from the elastic properties of the material in the

~~muscles~~ *VISCOELASTIC DEVICES* are made of and its mass. Our ~~muscles~~ *VISCOELASTIC* form and mass dictate specific motion

outcomes. Our ~~muscles~~ *VISCOELASTIC DEVICES* can be attached to the proximal end of our calf shank, below ~~the~~ *VISCOELASTIC DEVICES*

knee prosthetic socket, and/or thigh cuff on any combination thereof. Our ~~muscles~~ *VISCOELASTIC DEVICES*

distal attachment could be the distal end of the ~~calf~~ *VISCOELASTIC DEVICES* shank, posterior 1/3rd of the foot

keel, and/or foot keel or any combination thereof. Our ~~muscles~~ *VISCOELASTIC DEVICES* are not specifically

meant for the foot, ankle, and ~~calf~~ *VISCOELASTIC DEVICES* shank but can be utilized at the hip knee, ankle, toes,

elbow, wrist, fingers, shoulder, trunk, neck, eyes, ears, mouth, thumb, and/or any

combination thereof. Our ~~prosthetic muscle~~ *VISCOELASTIC DEVICES* can be cross sectional shaped as a: *FIG 9 A* *FIG 10 A* *FIG 11 A* *FIG 12 A* *FIG 13 A* *FIG 14 A* *FIG 15 A* *FIG 16 A* *FIG 17 A* *FIG 18 A* *FIG 19 A* *FIG 20 A* *FIG 21 A* *FIG 22 A* *FIG 23 A* *FIG 24 A* *FIG 25 A* *FIG 26 A* *FIG 27 A* *FIG 28 A* *FIG 29 A* *FIG 30 A* *FIG 31 A* *FIG 32 A* *FIG 33 A* *FIG 34 A* *FIG 35 A* *FIG 36 A* *FIG 37 A* *FIG 38 A* *FIG 39 A* *FIG 40 A* *FIG 41 A* *FIG 42 A* *FIG 43 A* *FIG 44 A* *FIG 45 A* *FIG 46 A* *FIG 47 A* *FIG 48 A* *FIG 49 A* *FIG 50 A* *FIG 51 A* *FIG 52 A* *FIG 53 A* *FIG 54 A* *FIG 55 A* *FIG 56 A* *FIG 57 A* *FIG 58 A* *FIG 59 A* *FIG 60 A* *FIG 61 A* *FIG 62 A* *FIG 63 A* *FIG 64 A* *FIG 65 A* *FIG 66 A* *FIG 67 A* *FIG 68 A* *FIG 69 A* *FIG 70 A* *FIG 71 A* *FIG 72 A* *FIG 73 A* *FIG 74 A* *FIG 75 A* *FIG 76 A* *FIG 77 A* *FIG 78 A* *FIG 79 A* *FIG 80 A* *FIG 81 A* *FIG 82 A* *FIG 83 A* *FIG 84 A* *FIG 85 A* *FIG 86 A* *FIG 87 A* *FIG 88 A* *FIG 89 A* *FIG 90 A* *FIG 91 A* 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A* *FIG 343 A* *FIG 344 A* *FIG 345 A* *FIG 346 A* *FIG 347 A* *FIG 348 A* *FIG 349 A* *FIG 350 A* *FIG 351 A* *FIG 352 A* *FIG 353 A* *FIG 354 A* *FIG 355 A* *FIG 356 A* *FIG 357 A* *FIG 358 A* *FIG 359 A* *FIG 360 A* *FIG 361 A* *FIG 362 A* *FIG 363 A* *FIG 364 A* *FIG 365 A* *FIG 366 A* *FIG 367 A* *FIG 368 A* *FIG 369 A* *FIG 370 A* *FIG 371 A* *FIG 372 A* *FIG 373 A* *FIG 374 A* *FIG 375 A* *FIG 376 A* *FIG 377 A* *FIG 378 A* *FIG 379 A* *FIG 380 A* *FIG 381 A* *FIG 382 A* *FIG 383 A* *FIG 384 A* *FIG 385 A* *FIG 386 A* *FIG 387 A* *FIG 388 A* *FIG 389 A* *FIG 390 A* *FIG 391 A* *FIG 392 A* *FIG 393 A* *FIG 394 A* *FIG 395 A* *FIG 396 A* *FIG 397 A* *FIG 398 A* *FIG 399 A* *FIG 400 A* *FIG 401 A* *FIG 402 A* *FIG 403 A* *FIG 404 A* *FIG 405 A* *FIG 406 A* *FIG 407 A* *FIG 408 A* *FIG 409 A* *FIG 410 A* *FIG 411 A* *FIG 412 A* *FIG 413 A* *FIG 414 A* *FIG 415 A* *FIG 416 A* *FIG 417 A* *FIG 418 A* *FIG 419 A* *FIG 420 A* *FIG 421 A* *FIG 422 A* *FIG 423 A* *FIG 424 A* *FIG 425 A* *FIG 426 A* *FIG 427 A* *FIG 428 A* *FIG 429 A* *FIG 430 A* *FIG 431 A* *FIG 432 A* *FIG 433 A* *FIG 434 A* *FIG 435 A* *FIG 436 A* *FIG 437 A* *FIG 438 A* *FIG 439 A* *FIG 440 A* *FIG 441 A* *FIG 442 A* *FIG 443 A* *FIG 444 A* *FIG 445 A* *FIG 446 A* *FIG 447 A* *FIG 448 A* *FIG 449 A* *FIG 450 A* *FIG 451 A* *FIG 452 A* *FIG 453 A* *FIG 454 A* *FIG 455 A* *FIG 456 A* *FIG 457 A* *FIG 458 A* *FIG 459 A* *FIG 460 A* *FIG 461 A* *FIG 462 A* *FIG 463 A* *FIG 464 A* *FIG 465 A* *FIG 466 A* *FIG 467 A* *FIG 468 A* *FIG 469 A* *FIG 470 A* *FIG 471 A* *FIG 472 A* *FIG 473 A* *FIG 474 A* *FIG 475 A* *FIG 476 A* *FIG 477 A* *FIG 478 A* *FIG 479 A* *FIG 480 A* *FIG 481 A* *FIG 482 A* *FIG 483 A* *FIG 484 A* *FIG 485 A* *FIG 486 A* *FIG 487 A* *FIG 488 A* *FIG 489 A* *FIG 490 A* *FIG 491 A* *FIG 492 A* *FIG 493 A* *FIG 494 A* *FIG 495 A* *FIG 496 A* *FIG 497 A* *FIG 498 A* *FIG 499 A* *FIG 500 A* *FIG 501 A* *FIG 502 A* *FIG 503 A* *FIG 504 A* *FIG 505 A* *FIG 506 A* *FIG 507 A* *FIG 508 A* *FIG 509 A* *FIG 510 A* *FIG 511 A* *FIG 512 A* *FIG 513 A* *FIG 514 A* *FIG 515 A* *FIG 516 A* *FIG 517 A* *FIG 518 A* *FIG 519 A* *FIG 520 A* *FIG 521 A* *FIG 522 A* *FIG 523 A* *FIG 524 A* *FIG 525 A* *FIG 526 A* *FIG 527 A* *FIG 528 A* *FIG 529 A* *FIG 530 A* *FIG 531 A* *FIG 532 A* *FIG 533 A* *FIG 534 A* *FIG 535 A* *FIG 536 A* *FIG 537 A* *FIG 538 A* *FIG 539 A* *FIG 540 A* *FIG 541 A* *FIG 542 A* *FIG 543 A* *FIG 544 A* *FIG 545 A* *FIG 546 A* *FIG 547 A* *FIG 548 A* *FIG 549 A* *FIG 550 A* *FIG 551 A* *FIG 552 A* *FIG 553 A* *FIG 554 A* *FIG 555 A* *FIG 556 A* *FIG 557 A* *FIG 558 A* *FIG 559 A* *FIG 560 A* *FIG 561 A* *FIG 562 A* *FIG 563 A* *FIG 564 A* *FIG 565 A* *FIG 566 A* *FIG 567 A* *FIG 568 A* *FIG 569 A* *FIG 570 A* *FIG 571 A* *FIG 572 A* *FIG 573 A* *FIG 574 A* *FIG 575 A* *FIG 576 A* *FIG 577 A* *FIG 578 A* *FIG 579 A* *FIG 580 A* *FIG 581 A* *FIG 582 A* *FIG 583 A* *FIG 584 A* *FIG 585 A* *FIG 586 A* *FIG 587 A* *FIG 588 A* *FIG 589 A* *FIG 590 A* *FIG 591 A* *FIG 592 A* *FIG 593 A* *FIG 594 A* *FIG 595 A* *FIG 596 A* *FIG 597 A* *FIG 598 A* *FIG 599 A* *FIG 600 A* *FIG 601 A* *FIG 602 A* *FIG 603 A* *FIG 604 A* *FIG 605 A* *FIG 606 A* *FIG 607 A* *FIG 608 A* *FIG 609 A* *FIG 610 A* *FIG 611 A* *FIG 612 A* *FIG 613 A* *FIG 614 A* *FIG 615 A* *FIG 616 A* *FIG 617 A* *FIG 618 A* *FIG 619 A* *FIG 620 A* *FIG 621 A* *FIG 622 A* *FIG 623 A* *FIG 624 A* *FIG 625 A* *FIG 626 A* *FIG 627 A* *FIG 628 A* *FIG 629 A* *FIG 630 A* *FIG 631 A* *FIG 632 A* *FIG 633 A* *FIG 634 A* *FIG 635 A* *FIG 636 A* *FIG 637 A* *FIG 638 A* *FIG 639 A* *FIG 640 A* *FIG 641 A* *FIG 642 A* *FIG 643 A* *FIG 644 A* *FIG 645 A* *FIG 646 A* *FIG 647 A* *FIG 648 A* *FIG 649 A* *FIG 650 A* *FIG 651 A* *FIG 652 A* *FIG 653 A* *FIG 654 A* *FIG 655 A* *FIG 656 A* *FIG 657 A* *FIG 658 A* *FIG 659 A* *FIG 660 A* *FIG 661 A* *FIG 662 A* *FIG 663 A* *FIG 664 A* *FIG 665 A* *FIG 666 A* *FIG 667 A* *FIG 668 A* *FIG 669 A* *FIG 670 A* *FIG 671 A* *FIG 672 A* *FIG 673 A* *FIG 674 A* *FIG 675 A* *FIG 676 A* *FIG 677 A* *FIG 678 A* *FIG 679 A* *FIG 680 A* *FIG 681 A* *FIG 682 A* *FIG 683 A* *FIG 684 A* *FIG 685 A* *FIG 686 A* *FIG 687 A* *FIG 688 A* *FIG 689 A* *FIG 690 A* *FIG 691 A* *FIG 692 A* *FIG 693 A* *FIG 694 A* *FIG 695 A* *FIG 696 A* *FIG 697 A* *FIG 698 A* *FIG 699 A* *FIG 700 A* *FIG 701 A* *FIG 702 A* *FIG 703 A* *FIG 704 A* *FIG 705 A* *FIG 706 A* *FIG 707 A* *FIG 708 A* *FIG 709 A* *FIG 710 A* *FIG 711 A* *FIG 712 A* *FIG 713 A* *FIG 714 A* *FIG 715 A* *FIG 716 A* *FIG 717 A* *FIG 718 A* *FIG 719 A* *FIG 720 A* *FIG 721 A* *FIG 722 A* *FIG 723 A* *FIG 724 A* *FIG 725 A* *FIG 726 A* *FIG 727 A* *FIG 728 A* *FIG 729 A* *FIG 730 A* *FIG 731 A* *FIG 732 A* *FIG 733 A* *FIG 734 A* *FIG 735 A* *FIG 736 A* *FIG 737 A* *FIG 738 A* *FIG 739 A* *FIG 740 A* *FIG 741 A* *FIG 742 A* *FIG 743 A* *FIG 744 A* *FIG 745 A* *FIG 746 A* *FIG 747 A* *FIG 748 A* *FIG 749 A* *FIG 750 A* *FIG 751 A* *FIG 752 A* *FIG 753 A* *FIG 754 A* *FIG 755 A* *FIG 756 A* *FIG 757 A* *FIG 758 A* *FIG 759 A* *FIG 760 A* *FIG 761 A* *FIG 762 A* *FIG 763 A* *FIG 764 A* *FIG 765 A* *FIG 766 A* *FIG 767 A* *FIG 768 A* *FIG 769 A* *FIG 770 A* *FIG 771 A* *FIG 772 A* *FIG 773 A* *FIG 774 A* *FIG 775 A* *FIG 776 A* *FIG 777 A* *FIG 778 A* *FIG 779 A* *FIG 780 A* *FIG 781 A* *FIG 782 A* *FIG 783 A* *FIG 784 A* *FIG 785 A* *FIG 786 A* *FIG 787 A* *FIG 788 A* *FIG 789 A* *FIG 790 A* *FIG 791 A* *FIG 792 A* *FIG 793 A* *FIG 794 A* *FIG 795 A* *FIG 796 A* *FIG 797 A* *FIG 798 A* *FIG 799 A* *FIG 800 A* *FIG 801 A* *FIG 802 A* *FIG 803 A* *FIG 804 A* *FIG 805 A* *FIG 806 A* *FIG 807 A* *FIG 808 A* *FIG 809 A* *FIG 810 A* *FIG 811 A* *FIG 812 A* *FIG 813 A* *FIG 814 A* *FIG 815 A* *FIG 816 A* *FIG 817 A* *FIG 818 A* *FIG 819 A* *FIG 820 A* *FIG 821 A* *FIG 822 A* *FIG 823 A* *FIG 824 A* *FIG 825 A* *FIG 826 A* *FIG 827 A* *FIG 828 A* *FIG 829 A* *FIG 830 A* *FIG 831 A* *FIG 832 A* *FIG 833 A* *FIG 834 A* *FIG 835 A* *FIG 836 A* *FIG 837 A* *FIG 838 A* *FIG 839 A* *FIG 840 A* *FIG 841 A* *FIG 842 A* *FIG 843 A* *FIG 844 A* *FIG 845 A* *FIG 846 A* *FIG 847 A* *FIG 848 A* *FIG 849 A* *FIG 850 A* *FIG 851 A* *FIG 852 A* *FIG 853 A* *FIG 854 A* *FIG 855 A* *FIG 856 A* *FIG 857 A* *FIG 858 A* *FIG 859 A* *FIG 860 A* *FIG 861 A* *FIG 862 A* *FIG 863 A* *FIG 864 A* *FIG 865 A* *FIG 866 A* *FIG 867 A* *FIG 868 A* *FIG 869 A* *FIG 870 A* *FIG 871 A* *FIG 872 A* *FIG 873 A* *FIG 874 A* *FIG 875 A* *FIG 876 A* *FIG 877 A* *FIG 878 A* *FIG 879 A* *FIG 880 A* *FIG 881 A* *FIG 882 A* *FIG 883 A* *FIG 884 A* *FIG 885 A* *FIG 886 A* *FIG 887 A* *FIG 888 A* *FIG 889 A* *FIG 890 A* *FIG 891 A* *FIG 892 A* *FIG 893 A* *FIG 894 A* *FIG 895 A* *FIG 896 A* *FIG 897 A* *FIG 898 A* *FIG 899 A* *FIG 900 A* *FIG 901 A* *FIG 902 A* *FIG 903 A* *FIG 904 A* *FIG 905 A* *FIG 906 A* *FIG 907 A* *FIG 908 A* *FIG 909 A* *FIG 910 A* *FIG 911 A* *FIG 912 A* *FIG 913 A* *FIG 914 A* *FIG 915 A* *FIG 916 A* *FIG 917 A* *FIG 918 A* *FIG 919 A* *FIG 920 A* *FIG 921 A* *FIG 922 A* *FIG 923 A* *FIG 924 A* *FIG 925 A* *FIG 926 A* *FIG 927 A* *FIG 928 A* *FIG 929 A* *FIG 930 A* *FIG 931 A* *FIG 932 A* *FIG 933 A* *FIG 934 A* *FIG 935 A* *FIG 936 A* *FIG 937 A* *FIG 938 A* *FIG 939 A* *FIG 940 A* *FIG 941 A* *FIG 942 A* *FIG 943 A* *FIG 94*

VISCOELASTIC DEVICES

Our ~~artificial muscles~~ viscoelastic devices elastic and form characteristics can be manipulated by design form to replicate the function of any muscle in the human body. Wherein every human muscle has a specific motion and function capability. Our ~~muscles~~ viscoelastic devices can be a hybrid of bio-mechanical forms wherein biological tissues are interfused with mechanical elements to create structures capable of contracting, i.e. shortening with electrical input. Our ~~muscles~~ viscoelastic devices can be a hybrid of elastic mechanical elements capable of responding to an electrical stimulus wherein the electrical stimulus makes the mechanical elements shorten in length causing a shortening of the ~~muscles~~ viscoelastic device length. Our ~~muscles~~ viscoelastic devices are beyond simple synthetic rubber.

(Our prosthetic foot keel and calf shank resilient - all) WHAT?

The design of our ~~muscles~~ viscoelastic devices terminal ends can be integral or monolithically formed with the body and/or central region. The terminal end can have a male or female dove-tail wherein the opposite design is integrally or monolithically formed to its mate (See figure 20 A+B+C). The dove-tail can be oriented to be at 90° to 0°. The mate to the ~~muscle~~ viscoelastic device terminal end can be made of an alloy, rubber, plastic or any combination thereof. The terminal end of our muscle can be formed with an elastic and/or non-elastic material (see figure 20 C). Our ~~muscles~~ viscoelastic terminal end can have a length adjustment fastener

attachment wherein the muscle can be tensioned by shortening the over all length of the ~~muscle~~ viscoelastic device (see figure 21, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100). Our ~~muscles~~ viscoelastic device terminal ends can be any combination of the aforementioned designs. Our ~~muscles~~ viscoelastic can be made of a fibrous elastic element that can be expanded to produce movements for the joints they cross and/or for the human structure they are intended to mimic. Our ~~muscles~~ viscoelastic device can bebrainstorm here _____.

VISCOELASTIC FOR

Artificial muscle resilient leaf spring design, see figure 21^A, this ~~muscle~~ ^{COMP SPRING} design

incorporates a single and/or multiple leaf springs. The leaf springs can be made of rubber, plastic, alloy and/or composite the resiliency of the material and form dictating its functional motion outcomes. The leaf spring can be single and/or multilayered and they can be of the same and/or different lengths. The general shape of the leaf spring is curvilinear with a straight section and/or curvilinear throughout. The leaf springs can respond to a force by compressing and/or expanding. Our leaf springs can be made in a variety of lengths, they can be layered in multiple layers. The strap material for our leaf spring muscle can be single or multilayered. The strap can be non-stretching and/or stretchable. The function of our leaf spring ^{pedice} ~~muscle~~ is to replicate the function of a human muscle. Our leaf springs can be made of a resilient material and/or resilient materials or any combination thereof to facilitate the same and/or different spring rates. Our leaf springs can be monolithically and/or integrally formed. Our leaf spring can be fusiform, bi-pinnate, and/or multi-pinnate. Our leaf springs can be formed with a middle section single and/or multiple cutouts.

Our cutouts can be rectangular, square, triangular, poly angular, round/circular, half moon, crescent moon in shape (See tab 2 with drawn shapes). The leaf springs can be bar stock and/or non-bar stock in shape, see figure below (m, n, o, p, q, r, s) ^{m n o p}
^{q q1 R S}

Our leaf springs can have symmetry and/or asymmetrical form. Our leaf spring can have varied spring rates within the monolithic form, wherein, the spring rate can be

softer and/or firmer depending on the curvilinear forms. For example (see ^{Figure R} ~~drawing on~~ 230). X+Y and A-C can be the same or different widths, the spring rate of each section of the leaf spring being related to the width and thickness of the leaf spring in (figure R on 230) was the same from top to bottom, the width of X, Y, A, B, and C would dictate spring rates for that area of the structure. This varied width design allows a single structure to have varied spring rates wherein the spring rates can be firmer and/or softer. For example, X would be softer than Y, and C softer than B, and B softer than A. This allows us to create a varied spring rate with one structure. This varied spring rate can be appreciated by the amputee because ^{of} ~~on~~ varied force loading ^{or} ~~of~~ the prosthetic system which occurs during walking, running, and jumping activities, the spring rate would ramp up. The leaf spring below is an example. Figure S (233) section 1 would have less spring rate than section 2 and 3. As a consequence the small force loading section 1 would respond as the forces go up; sections 2 and 3 would be utilized giving us a mechanical structure that ramps up its spring rate proportional to its force load.

Another varied embodiment would be to have a leaf spring that has a raised middle section that would engage as force loading increases. For example T1-4 (234-236). This particular leaf spring design does not have to be rectilinear in form but could be curvilinear in form combining both curvilinear and/or rectilinear forms. Anybody skilled in the prior art would know that our basic design principles could be combined to achieve a desired motion outcome.

^{AN}
~~Primary~~ objective of our prosthetic system/design is to have a foot keel, ankle, and shank that is highly flexible yet during the late mid-stance phase of gait the system becomes more rigid or when force loading goes up in running and jumping activities our structure becomes more rigid. This has been accomplished with our longitudinal foot keel and monolithically formed ankle and shank wherein the longitudinal arch area of the longitudinal foot keel and the parabolic shaped calf shank respond to the late mid-stance ground reaction force by expanding which increased the angular velocity potential of both structures which has proven to improve the ankle joints sagittal plane kinetic power generation value. The human ankle joint has two primary muscle groups which influence its ability to create torque and they are the anterior pretibial and posterior triceps surae muscle groups. The scientific literature suggests that an 11 to 1 torque ratio exists between these two muscle groups with the posterior group being 11. The biomechanical function of our ~~posterior~~ ^{VISCOELASTIC DEVICE} device whether it be a leaf spring and/or ~~artificial muscle~~ ^{MUSCLE} and/or windlass allows us to achieve this 11 to 1 posterior to anterior torque ratio. ~~ANOTHER OBJECTIVE 1,000,000~~

By preloading our shank and foot keel with our windlass and ~~calf~~ shank, and/or ~~calf~~ shank and foot keel devices we can fabricate more flexible foot keel and ~~calf~~ shank units which are highly mobile yet become more rigid on force loading further replicating the human structures movement and motion characteristics.

III. Windlass foot shell (~~THIS SHOULD BE AN ENTIRELY SEPARATE PROVISIONAL PATENT~~) ~~SPARK ABN PATENT.~~ ^{well let}

^{NOT DECIDE.}

Traditional cosmetic foot shells are simply cosmetic in nature not adding any degree of biomechanical function. Our windlass foot shell cover adds potential energy (PE) to the longitudinal foot keel, this increase in (PE), functions to increase the kinetic energy potential. Our windlass foot shell incorporates a single and/or multilayer of plantar elastic straps/bands which originate on the plantar surface posteriorly and insert on the plantar surface anteriorly. These elastic bands can be integrally and/or monolithically formed (see figure ~~15~~ ¹⁵). These plantar bands can be molded into the foot shell when the foot shell is manufactured, by injection molding (see figure ~~16~~ ¹⁶). These plantar bands can be solid bands, fusiform, and/or multi-pinnate formed. Any combination thereof can be utilized in our windlass foot shell system. For example a solid band can be layered with a fusiform and/or multi-pinnate formed bands. By varying the elastic band forms varied motion outcomes are created. Our windlass effect is not limited to the foot shell system. It can be created by attaching the elastic plantar bands to the anterior and posterior ends of the longitudinal foot keel of our prosthetic system. These plantar bands anterior and posterior attachments can be fastened by a fastener (as ~~really I would have never guessed – its all so clear!~~) and/or slipped over the terminal ends of the longitudinal foot keel (see figures ~~rivets and globs~~ ^{Fig 16}). Varied potential energy can be added to this system by the use of variable thickness longitudinal arch pads. ✓

Wherein, the user of the device would change the thickness the thickness of the longitudinal arch pad for higher or lower functioning activities such as walking, running, and jumping. For example, the user of our prosthetic system would use a thinner longitudinal arch pad for walking. When the user of our prosthetic system wants to run he/she would remove the thin longitudinal arch pad from their shoe and exchange it with

a thicker longitudinal arch pad: this thicker longitudinal arch pad would increase the tension on the plantar band. This increase in tension preload is accomplished because the longitudinal foot keel is more rigid than the plantar elastic bands and the distance the plantar elastic bands must travel from their terminal ends is larger. Therefore a thicker pad will increase the tension preload stretch on the plantar bands. In practice the user of our prosthetic system can add one and/or multipads to achieve a tension (preload) that suites their activity. A thicker longitudinal arch pad for increased activities.

IV. Cams, Pads, Bladders (Potential energy manipulating devices).

A device which functions to prestretch/preload or otherwise increase tension on our ~~artificial muscle~~ ^{VISCOPLASTIC DEVICE} is needed to allow the user of the prosthesis to add potential energy (PE) to his prosthetic system. An increase in P.E. will increase the kinetic energy which increases the propulsive force to propel the trailing limb and body forward for the next cycle. This cycle can be walking, running, and/or jumping activities. This preloading of our ~~artificial muscle~~ ^{VISCOPLASTIC DEVICE} and windlass bands also functions to increase the ratio of posterior to anterior ankle joint torque values.

11/12/18 These potential energy devices can be air bladders, cams, and/or pads. For example figures (~~11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100~~) shows several thicknesses of pads which can be utilized as previously discussed with our elastic bands an windlass device. Similar pads can be attached to the posterior and/or anterior aspect of a prosthetic device. For example figure (11) shows a pad added to the posterior aspect of a below knee socket. However, any one

skilled in the art would know that these pads could be used on the thigh, forearm, upper arm, hand, finger, neck, and/or any other prosthetic part to increase tension on our ~~artificial muscle~~ ^{VISCO ELASTIC} device.

Air Bladders

Pneumatic and hydraulic bladders can also be used to increase tension on our windlass and ~~artificial muscle~~ ^{VISCO ELASTIC} devices. For example figure (13) shows a pneumatic bladder

which is attached to the posterior aspect of below knee socket wherein the bladder is sandwiched between the socket and ~~artificial muscles and/or muscles~~ ^{VISCO ELASTIC DEVICE}. In practice this

pneumatic is inflated increasing the tension on our artificial muscles. This increase in tension preloading adds potential energy (PE) to our system. This (PE) is variable with a direct relationship to the volume of air and expansion of the device. To facilitate expansion of our air bladder in one direction for example the pneumatic bladder is encapsulated in a cloth sheath that has rigidity on the sides which is achieved by the weave and flexibility in the anterior and posterior direction for example. The cloth sheath can be made of Kevlar, composites, cotton, nylon, and/or synthetic materials.

Our pneumatic bladder can also be formed monolithically wherein the medial and lateral sides of the bladder are made more rigid and thicker ^{than} the anterior and posterior sides for example. The objective of our pneumatic bladder is to increase the width of the anterior and posterior dimension while keeping the medial and lateral width narrow. ^{FOR EXAMPLE}

The pneumatic bladder when used in our windlass system would increase the plantar to dorsal width while not increasing the medial and lateral dimension.

Cams

Another (PE) embodiment for our ~~artificial muscle~~ ^{VISCO ELASTIC DEVICES} system uses a cam device wherein the user of our prosthetic system can manipulate the cam by adjusting the cam to increase tension preload our ~~artificial muscle~~ ^{VISCO ELASTIC DEVICE}. These cam devices as shown in figures

14A ^{and} C can use a worm gear and/or a single or multiple screws to cause the cam to lower and/or raise to tension preload our ~~muscles~~ ^{VISCO ELASTIC DEVICES}. These cam devices can be attached to the proximal and/or distal end of our monolithically formed ~~cam~~ shank, however, as previously discussed they can be utilized on any prosthetic part that uses our ~~artificial muscle device~~ ^{VISCO ELASTIC}. The operation of our cam devices is straight forward. For example, our worm gear drive cam device allows the user to screw the worm gear in or out which transfers this rotating motion and power from the worm gear to the gear which is attached to the cam. Other gear types can be used in our cam such as helical, herringbone, bevel, and/or rack and pinion gears.

Figure 14A shows a cam device that does not use a gear operation but rather a simple single and/or multiple adjustment screw. This adjustment screw engages the lower end of the cam and by screwing the screw in and out the motion of the cam is affected. In operation this style of cam device uses the pressure of the artificial muscle to keep the cam engaged with the adjustment screw and/or screws.

Our cams can be made in several different embodiments figure 14C, shows two rotating spindles wherein one or multiple ~~muscles~~ ^{VISCO ELASTIC DEVICES} can be thread through and/or over the spindles. Figure 14B shows a different style of cam wherein the spindles can be free

to rotate and/or be fixed. Still figure 14A shows a solid cam wherein spindles are not used. This solid cam design can be made with sides that are longer than the middle to facilitate our ^{VISCO ELASTIC DEVICE} artificial muscle tracking. Our cams can be made using any combination of the aforementioned embodiment without straying from our teachings. These cam devices can be made of plastic, alloy, composites and/or any other suitable material.

The cam units can be made so they are not solid, they can be made with cutouts and hollows to decrease weight. *FIGURE 23 shows A CAM DEVICE MOUNTED ON A SHANK.*

-Alternate Embodiment

Cylinder - ~~CYLINDER~~ *CYLINDER*

Another embodiment for our cam device is a pneumatic, hydraulic, and/or electric cylinder (solenoid) system wherein two cylinders are employed. ^{FIGURE 24} One cylinder (solenoid) is located in our rigid ankle device and the other is located in our cam device see figure _____. This cylinder (solenoid) system is activated by the motion created in the calf shank during physical activity of the user. As the user force loads our prosthetic system anterior longitudinal foot keel the distal end of our calf shank engages the lower cylinder (solenoid) push rod which causes the upper cylinder (solenoid) push rod to engage the cam of the cam device (see figure 27B ^{*24}) in operation as anterior force loading increases the pressure on the lower cylinder increases proportionally which engages the upper cylinder proportionally which causes the cam to engage the muscle creating a proportional tension preload on the artificial muscle. As the force loading increases and/or decreases the tension on the ^{VISCO ELASTIC DEVICE} muscle is similarly affected. This creates an

opportunity to allow anterior foot keel variable force loads to dictate variable tension on the artificial muscle. As such this cylinder device creates variable motion outcomes of our calf shank system proportional to the users activities.

FIGURE 25 SHOWS A FEMALE MUSCLE ATTACHMENT
DEVICE ATTACHED TO A LEATHER + OR PLASTIC THIGH
WIRE, ^{KNEE} HINGES ARE ATTACHED TO BOTH THE THIGH CUFF
PILOT ON PLASTIC
AND A BELOW KNEE SOCKET. THIS ^{FEMALE} ATTACHMENT
PLATE COULD ALSO BE LOCATED ON THE BACK OF THE
CALF AREA OF A PROSTHETIC SOCKET.

FIGURE 26 shows an ALTERNATIVE WINDLASS
DEVICE WHICH IS SIMILAR TO FIG 27 THIS
WINDLASS CABLE CAN INCORPORATE A
VISCOELASTIC + OR LEAFSPRING DEVICE TO
ADD ~~BE~~ INCORPORATED ELASTIC ENERGY
STORAGE CAPACITY. THE ~~WINDLASS~~ WINDLASS
CABLE CAN BE A ~~STIFF~~ NON STRETCHABLE
+ OR ^{ELASTIC} ~~STRETCHABLE~~ STIFF + OR CABLE. THIS EMBODIMENT
ATTACHES THE PROXIMAL CABLE TO THE
~~ANTERIOR~~ ~~POSTERIOR~~ ~~PO~~ FOREFOOT REGION
OR THE FOOT KEEL. THIS WINDLASS
DEVICE CAN INCORPORATE ALL PREVIOUS
DISCUSSED VISCOELASTIC & LEAF SPRING DEVICES
CAN BLADDERS + PADS ARE ONE

SKILLED IN THE ART WOULD KNOW TO
INCREASE THE PE + EE OF THIS
DEVICE TO IMPROVE KINETIC POWER
GENERATION. FIG 28 SHOWS ~~THE~~
~~TWO CABLE~~ SINGLE CABLE SYSTEM THAT
RUNS THROUGH THE POSTERIOR ASPECT
OF THE FOOT KEEL THIS AREA
CAN INCLUDE TWO ROLLER WHEELS
SIMILAR IN DESIGN TO THE ROLLER WHEEL
THAT IS PROXIMAL TO THIS AREA. ANOTHER MODIFICATION
WOULD BE TO RUN THE CABLE THROUGH
TWO HOLES IN THE FOOT KEEL WHICH
ARE LOCATED MORE ANTERIORLY.

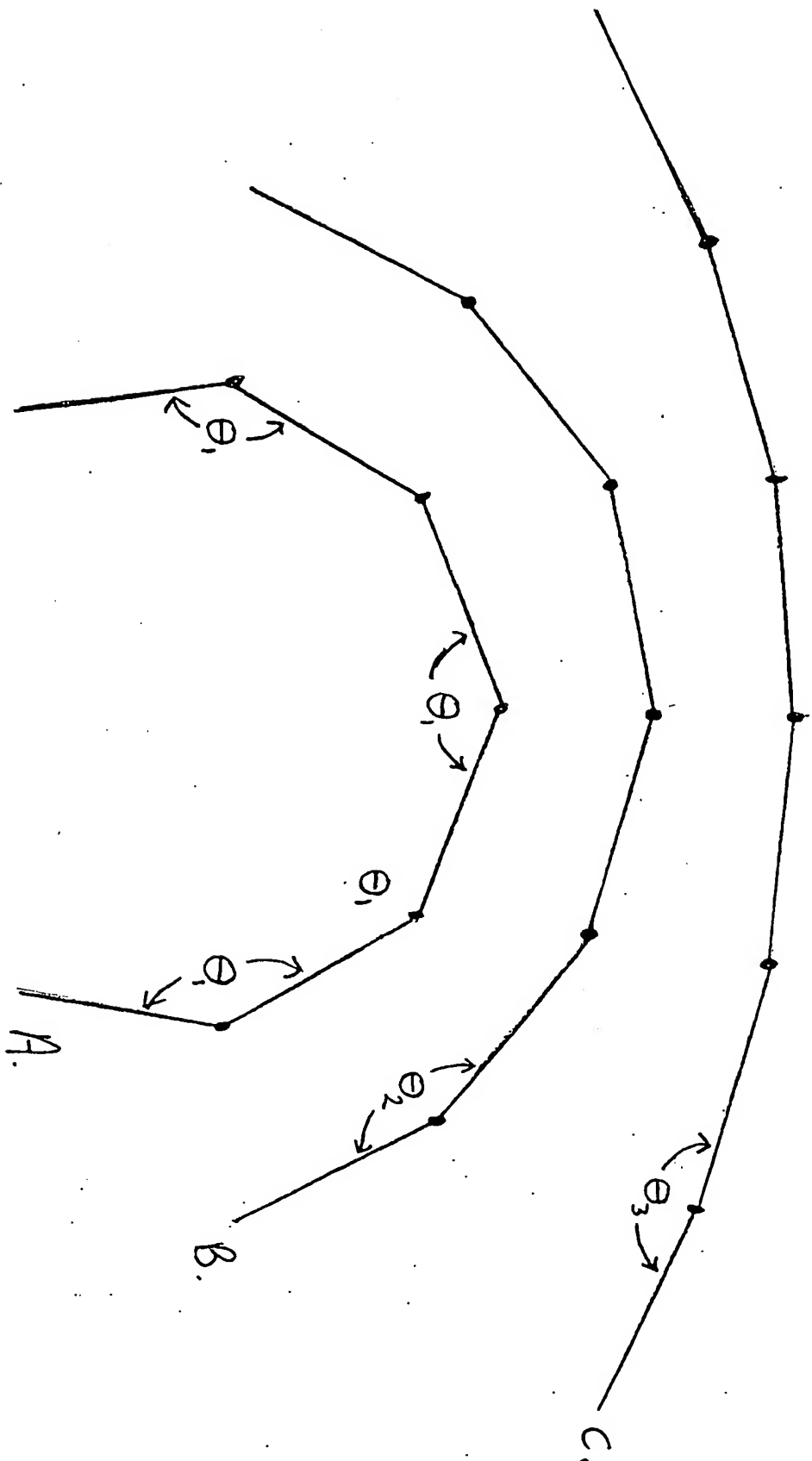
SAMPLE 29 SHOWS ANOTHER ALTERNATIVE EMBODIMENT TO OUR ARTIFICIAL MUSCLE DEVICE ~~FOR~~ SINGLE OR MULTI SPRING OR VARYING ELASTICITY COULD BE EMPLOYED IN THIS DESIGN. THE SPRINGS CAN BE MADE OF ALLOY, PLASTIC COMPOSITES, OR ANY OTHER SUITABLE MATERIAL WITH OUT VARYING FROM THE TEACHINGS ~~OF~~ OF THIS PATENT.

Attachment (A)

C. $\theta_3 = 170^\circ$

B. $\theta_2 = 155^\circ$

A. $\theta_1 = 140^\circ$



TO FURTHER SUPPORT OUR CONTENTION
 THAT THE ANGULAR VELOCITY OF A
 CURVILINEAR MECHANICAL STRUCTURE
 CAN BE ^{AFFECTED} POSITIVELY (INCREASED) + OR
 NEGATIVELY (DECREASED) BY THE DIRECTION
 OF MOVEMENT WHEREIN MOVEMENT
 OF THE ~~SP~~ CURVILINEAR STRUCTURE ^{CAUSES} CHANGES
 THE RADIUS ^{OF THE MECHANICAL STRUCTURE} TO INCREASE + OR DECREASE
 IN SIZE IN RESPONSE TO A ~~Q~~ FORCE. FIG. —

A B + C REPRESENT THREE CURVILINEAR
 STRUCTURES THAT HAVE BEEN CREATED
 BY ARTICULATING 6 SEPARATE LINK
 SEGMENTS ⁽¹⁾ WHICH THESE SEPARATE LINK
 SEGMENTS ARTICULATE AT ⁽¹⁾ + Θ CREATING

5 SEPARATE ^{BUT EQUAL} Θ ANGLES PER STRUCTURE.

STRUCTURE A HAS Θ_1 ANGLE OF 140°

② STRUCTURE B + C HAVE ~~THESE~~ $\Theta_2; \Theta_3$
ANGLES OF $155^\circ + 170^\circ$ RESPECTIVELY.

THE THREE STRUCTURES REPRESENT
THREE DIFFERENT RADI CURVILINEAR
STRUCTURES. ^{STRUCTURE} A HAVING A SMALLER RADIUS
THAN B AND B SMALLER THAN C.

ANGULAR VELOCITY IS DEFINED ~~AS~~ AS
ANGULAR CHANGE OVER TIME. IF STRUCTURE

A Θ_1 WAS CHANGED OVER TIME TO Θ_2

~~THE~~ THE CHANGE IN $\Theta_2 - \Theta_1$ REPRESENTS

⑥ A 15° INCREASE IN ANGULAR CHANGE ⁵⁰¹

FOR EACH Θ ANGLE. THIS SHOWS THAT

A MECHANICAL STRUCTURES ANGULAR
 VELOCITY CAN BE AFFECTED (INCREASED)
 OVER TIME AND ITS ANGULAR VELOCITY
 POTENTIAL IS DIRECTLY RELATED TO THE
 SIZE OF THE RADI CURVILINEAR
 STRUCTURE. SIMILARLY IF STRUCTURE
 C WAS CHANGED (OVER ^{THE SAME AFFORDMENT} ~~THE SAME~~
 TIME FRAME) TO STRUCTURE A IT
 WOULD REPRESENT A ^{DECREASE} ~~CHANGE~~ IN Θ
 $(\Theta_3 \text{ ~~170~~ } 170^\circ \text{ MINUS } \Theta_1, 140^\circ)$ OF
 30° . ^{IN THIS SCENARIO} SINCE THE Θ ANGLE IS
 GETTING SMALLER ^{WHICH CAUSES} A DECREASE IN
 ANGULAR VELOCITY POTENTIAL ~~IS~~
~~CREATED. BUT CANNOT BE~~

As previously discussed our prototypes
~~the~~ shank + longitudinal arch of the foot keel
 $P_1 + P_2$ Therfoot respond to late
(ground reaction force)
midstance phase of gait by expanding
~~the~~ this would represent ~~the~~ maximal

of figure A towards figure C
~~the~~ $\theta_{170} - \theta_{140} = 30^\circ$ increase in angular change
C ~~the~~ on the other hand the Plexfoot

monolithically shaped foot keel
ankle and shank ^{in response to this same (GRF)} would move

from figure C θ_{170}° to fig A

θ_{140}° ~~which is~~ ~~$\theta_{170} - \theta_{140}$~~ 30° decrease

in angular change. As a consequence

The ~~prementioned~~ prototype
~~the~~ structures having an increase

in angular velocity ^{potential} where as

The ~~the~~ Plexfoot prosthesis has a 50°

Decrease in Angular Velocity Potential.

As mentioned earlier in this
PROPOSAL ^{ANKLE JOINT KINETICS AS IT IS THE SAME} KINETIC Power EQUALS

~~THE~~ MOMENTS OF ~~THE~~ ANKLE JOINT
FORCE (which are very similar in
MAGNITUDE for the FlexRoot and
~~THE~~ PROTOTYPES) ~~THE~~ TIMES ANGULAR
VELOCITY, ~~AN INCREASE~~ SINCE
~~THE~~ ANGULAR VELOCITY IS A
PRODUCT OF MOMENTS OF FORCE
~~THE~~ AN INCREASE IN ANGULAR
VELOCITY WILL DIRECTLY & POSITIVELY
AFFECT THE KINETIC Power where
AS A DECREASE IN ANGULAR

Velocity will negatively affect
the kinetic power generation.

This is about as good as it
gets.

1,000,000 ANOTHER OBJECTIVE OF OUR ~~BY~~

VISCOELASTIC + LEAF SPRING ~~ELASTIC~~

ENERGY STORAGE DEVICES IS TO INCREASE

THE ELASTIC ENERGY STORAGE CAPACITY

OF THE ENTIRE ~~OF~~ PROSTHETIC SYSTEM. WITH

~~THE~~ EACH SEPARATE COMPONENT FOOT AND

SHANK ~~POSTERIOR~~ ~~OF~~ VISCOELASTIC + LEAF SPRING

DEVICE. HAVING ITS OWN ELASTIC ENERGY

STORAGE CAPACITY. WHERE IN THE COMPONENTS

CAN BE TUNED TO REPLICATE HUMAN ^{ANKLE} MOTION

FOR VARIOUS ACTIVITIES.

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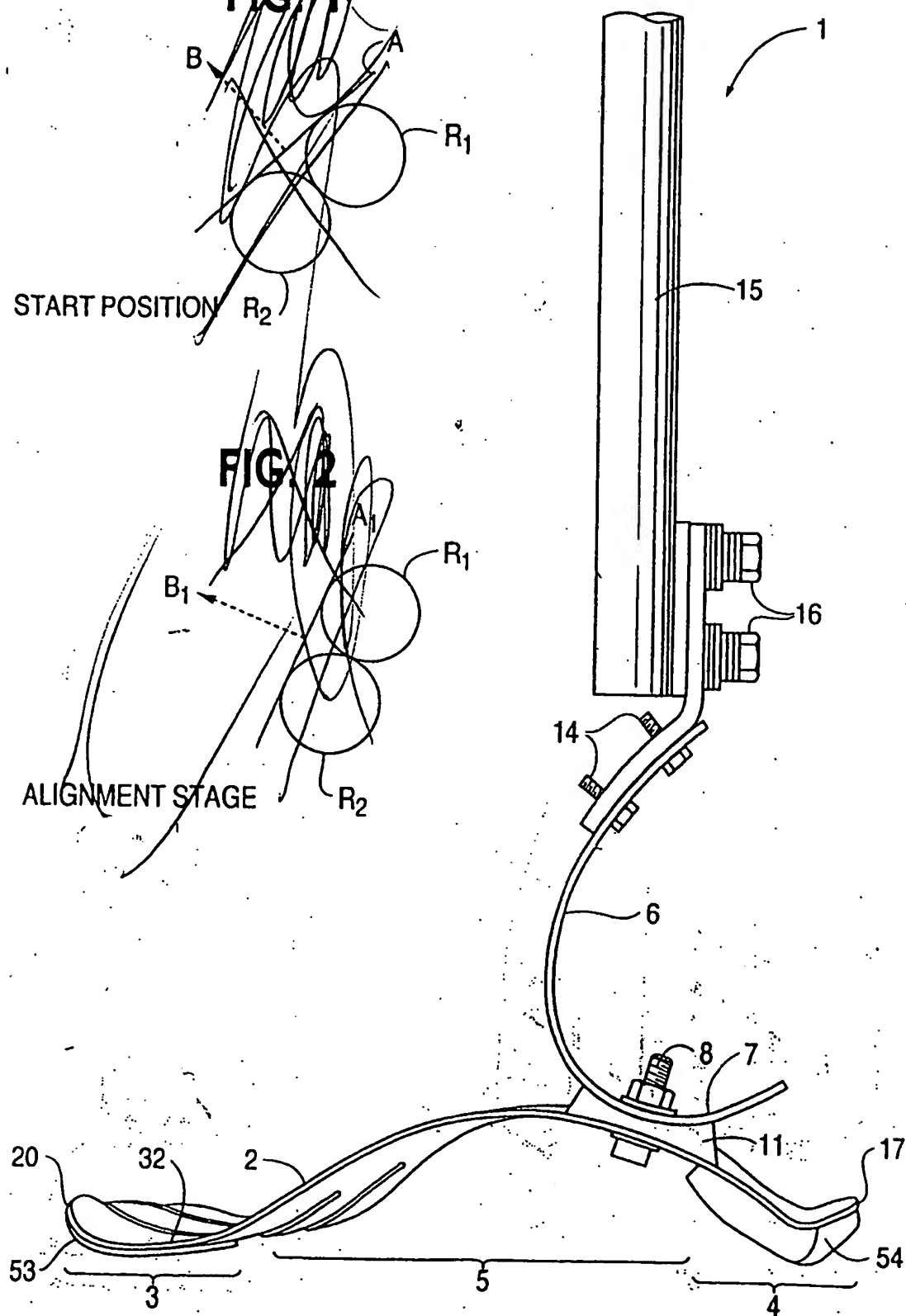


FIG. 25

P16 2

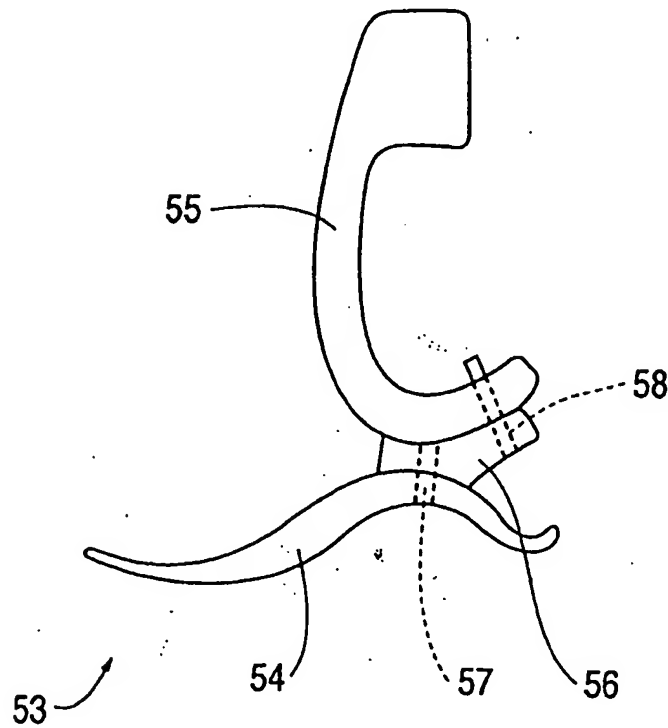
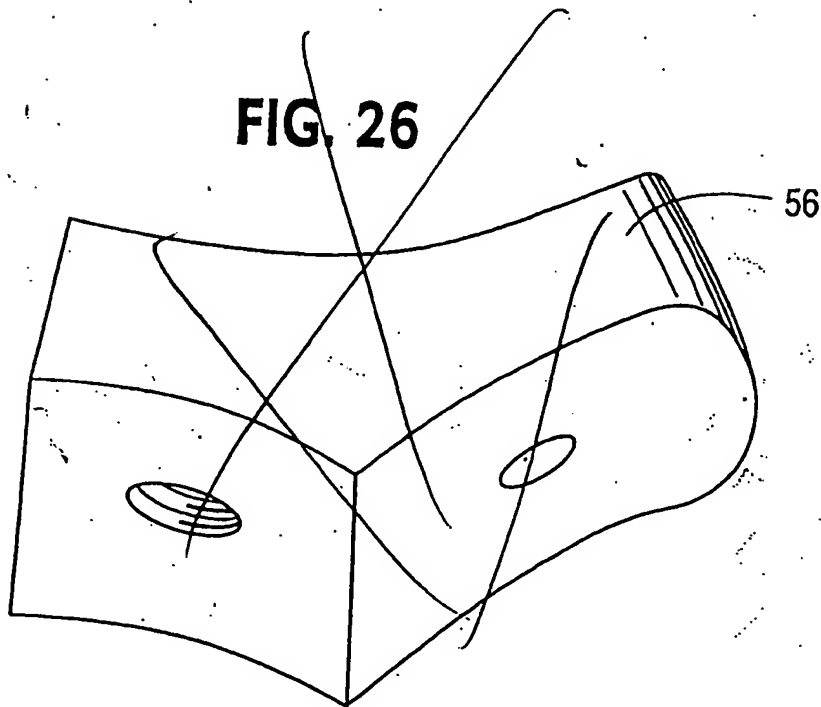


FIG. 26



TAB 3

TAB 4

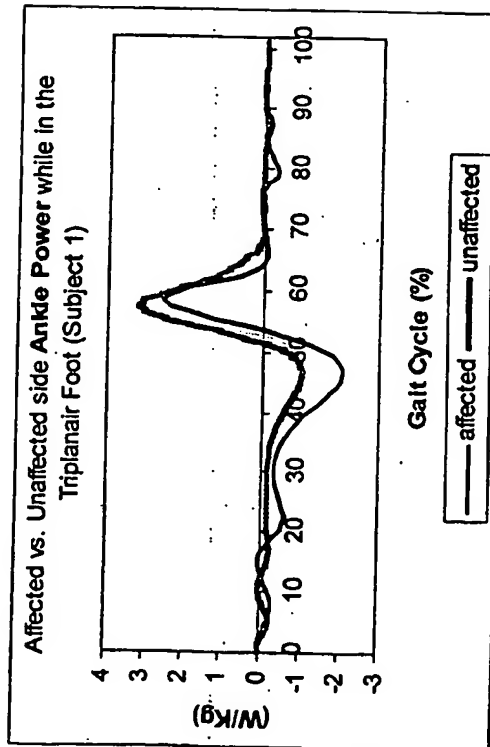
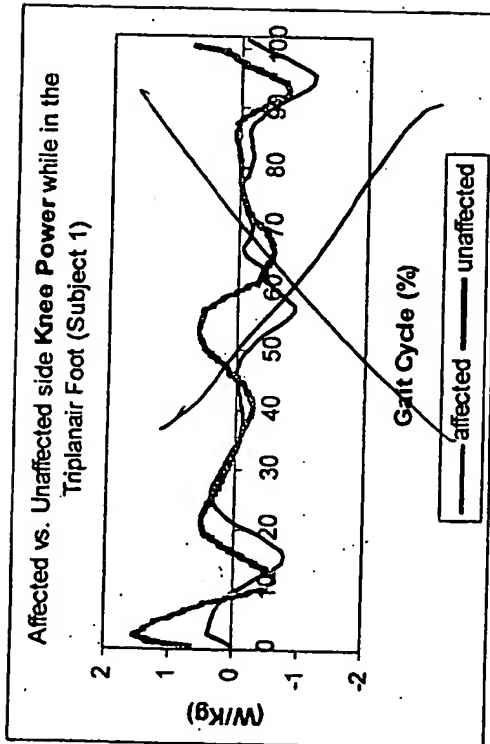
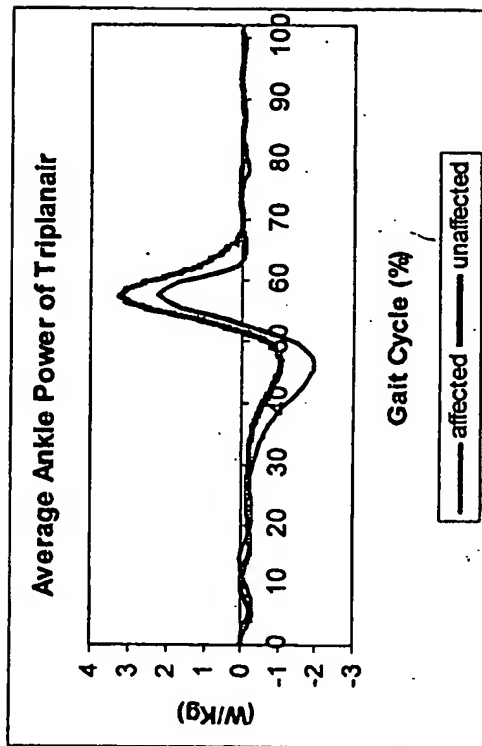
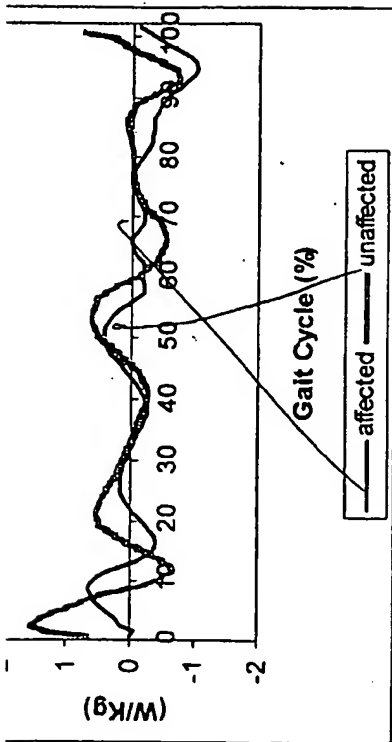


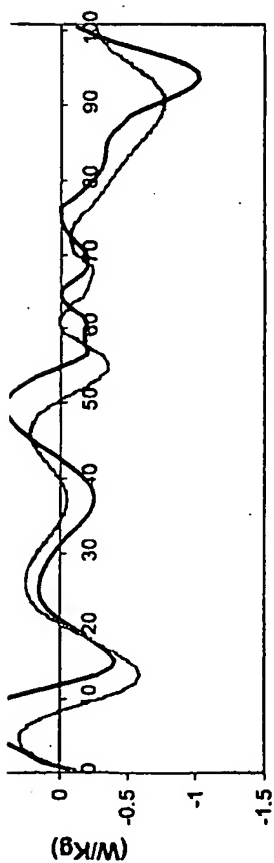
Fig 3

TAB 3

TAB 4



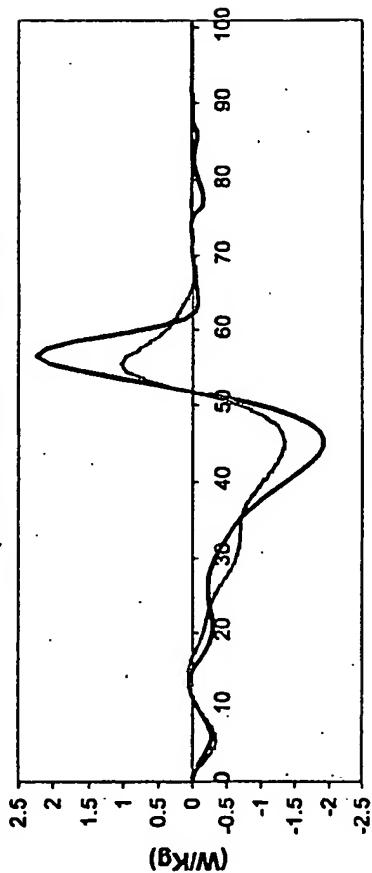
P164



Gait Cycle (%)

— triplanair — ff

Average Ankle Power Generation Curve of the Triplanair vs. the Flex-Foot



Gait Cycle (%)

— triplanair — ff

p16.5

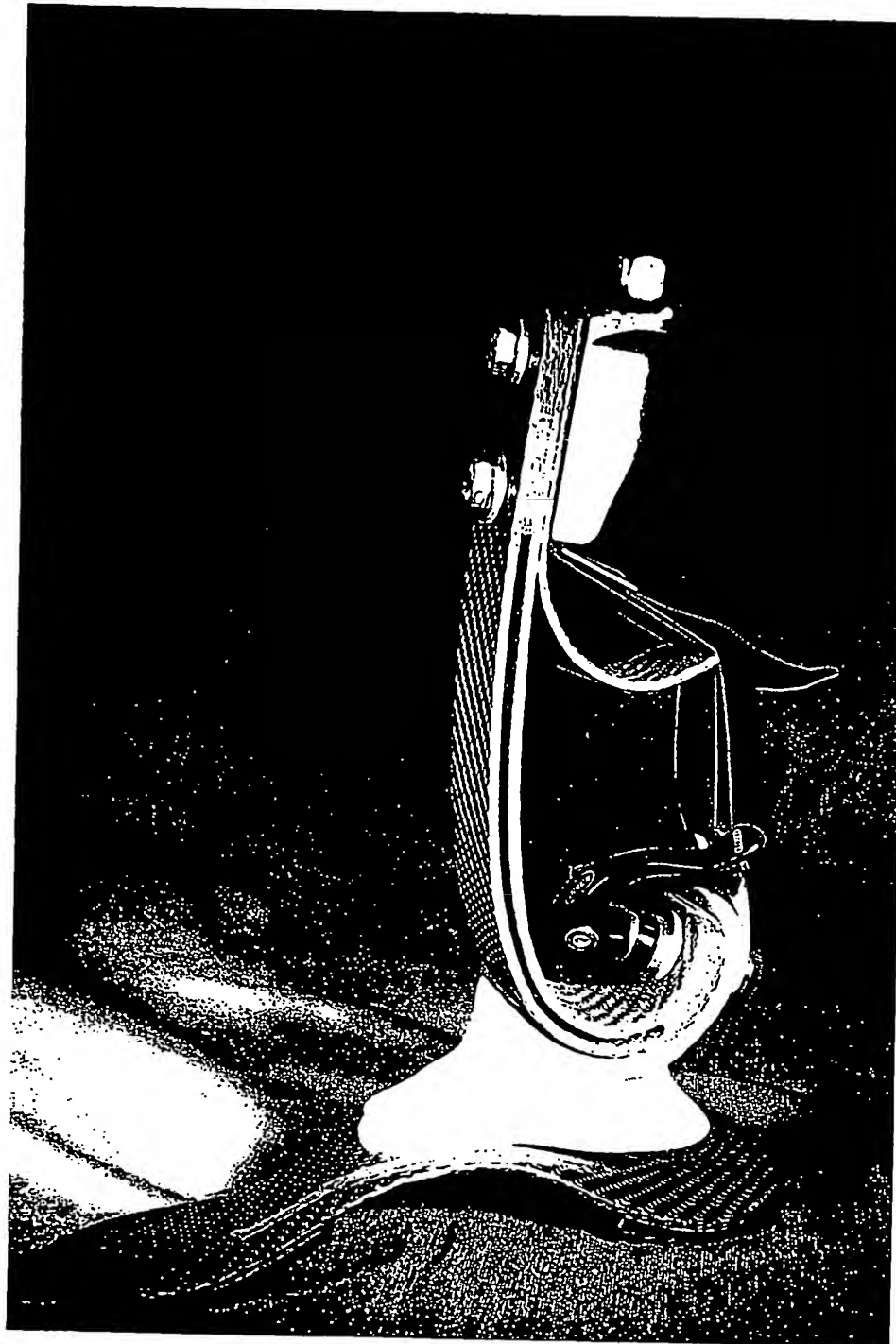


FIGURE 6

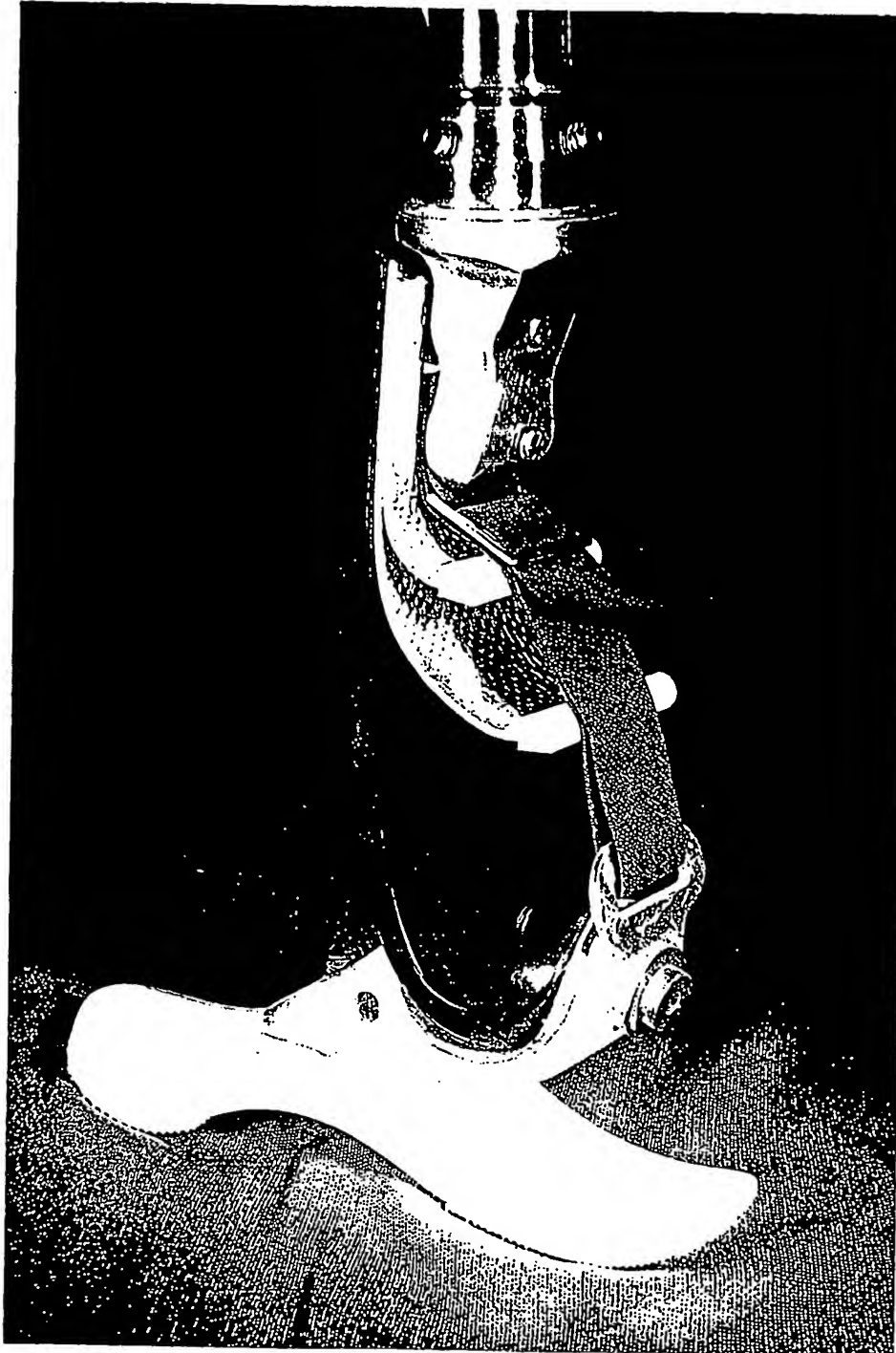
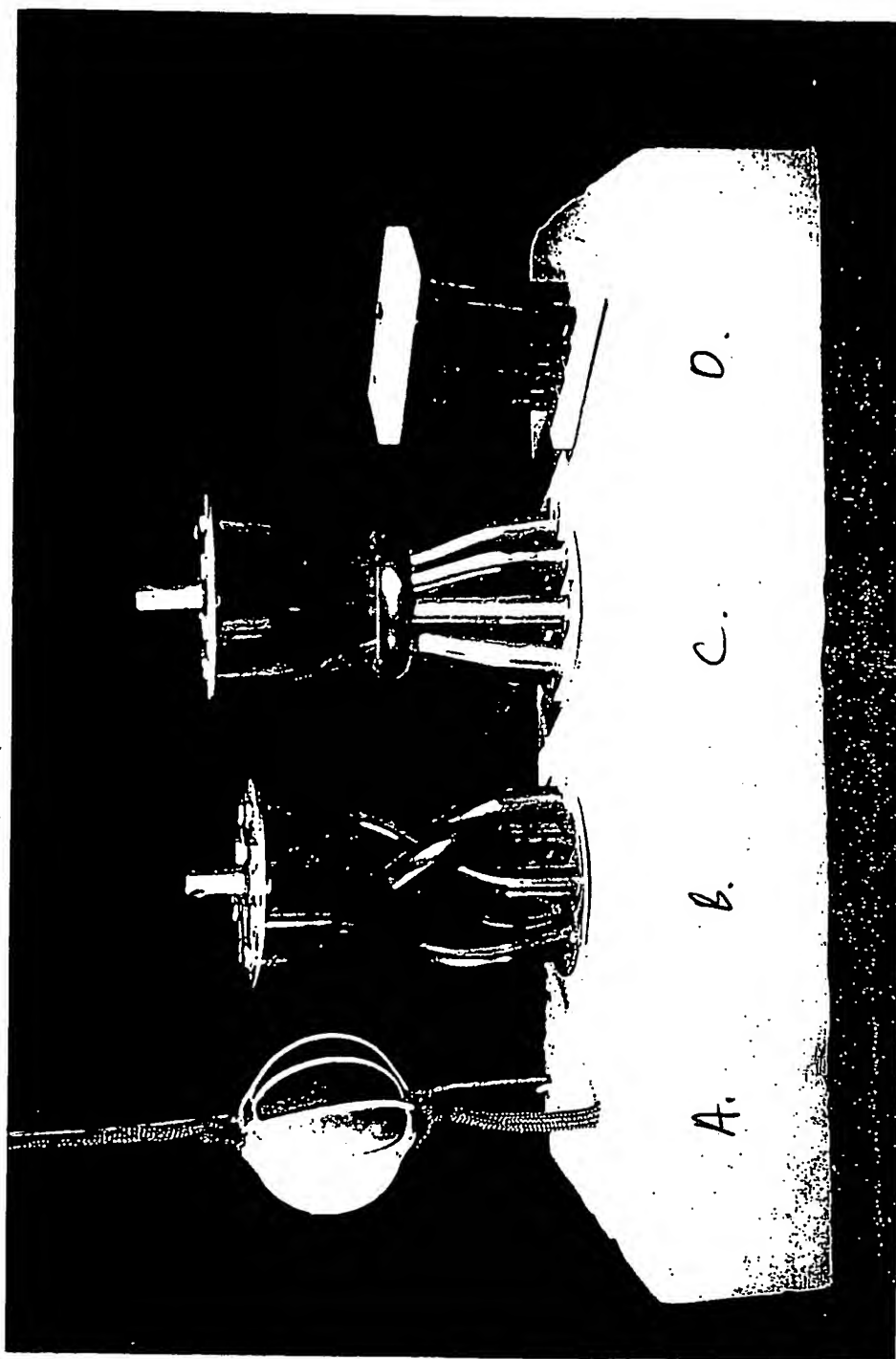
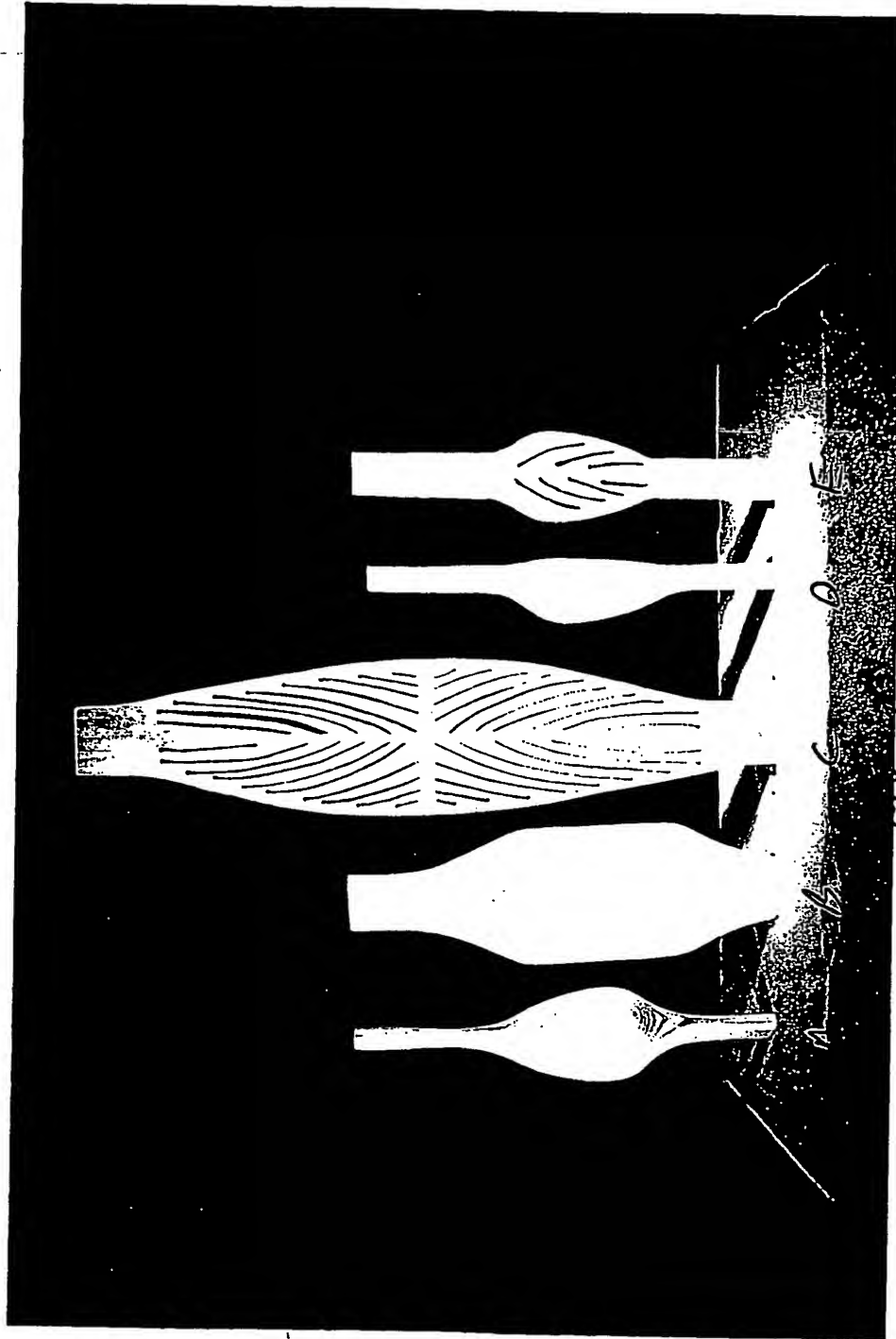


FIGURE 7





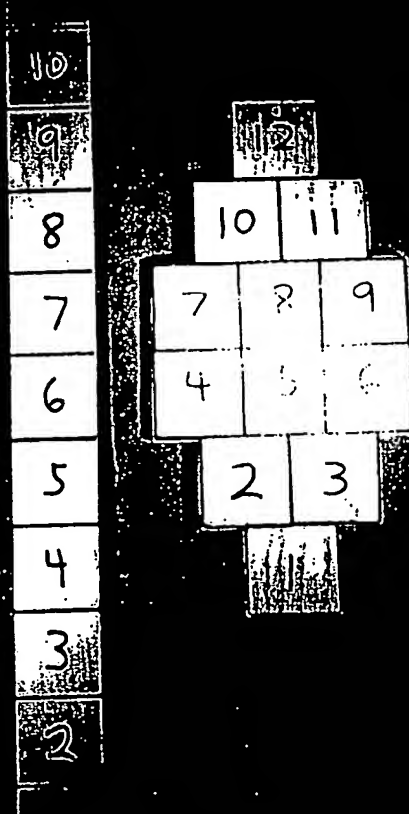
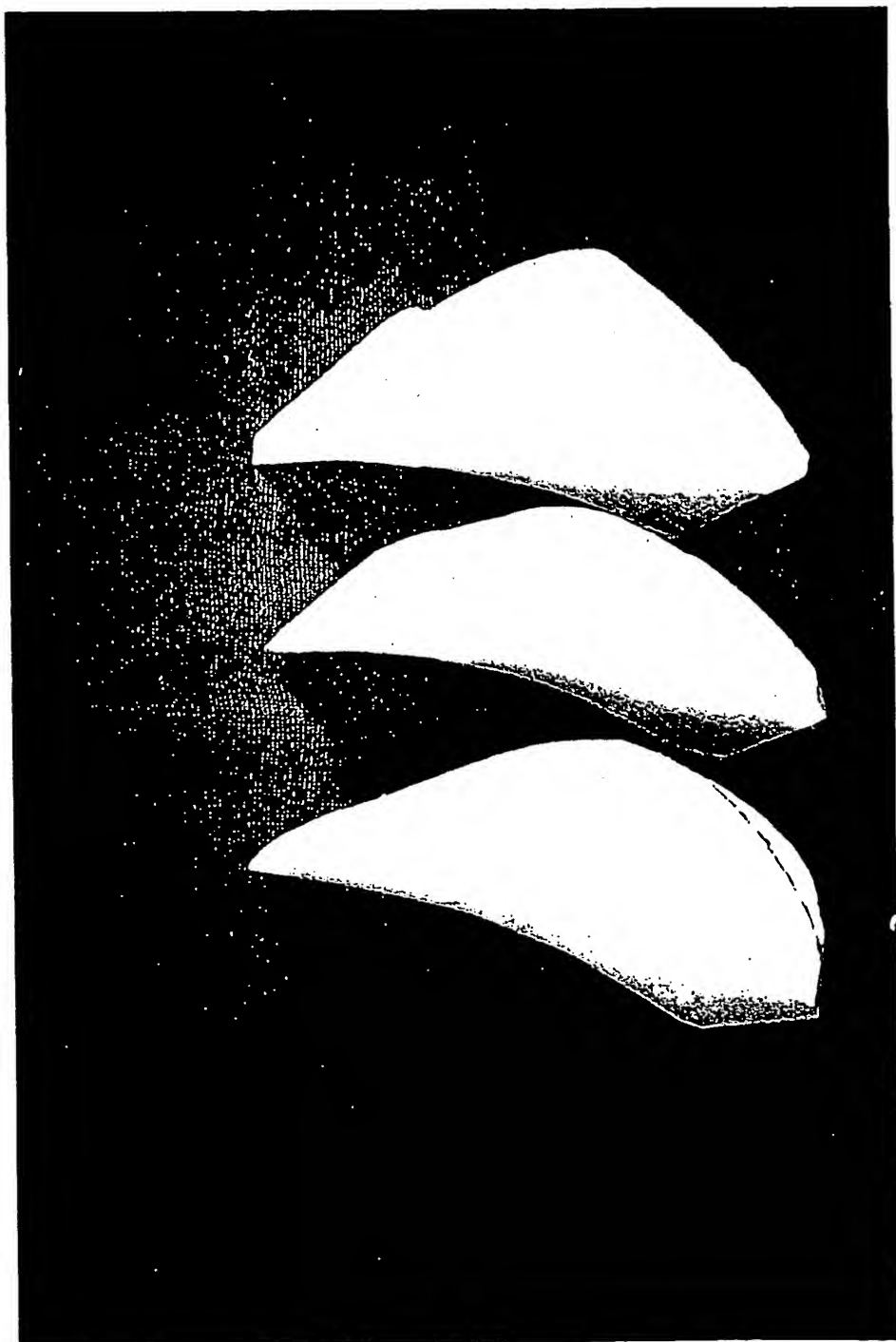


Figure 10



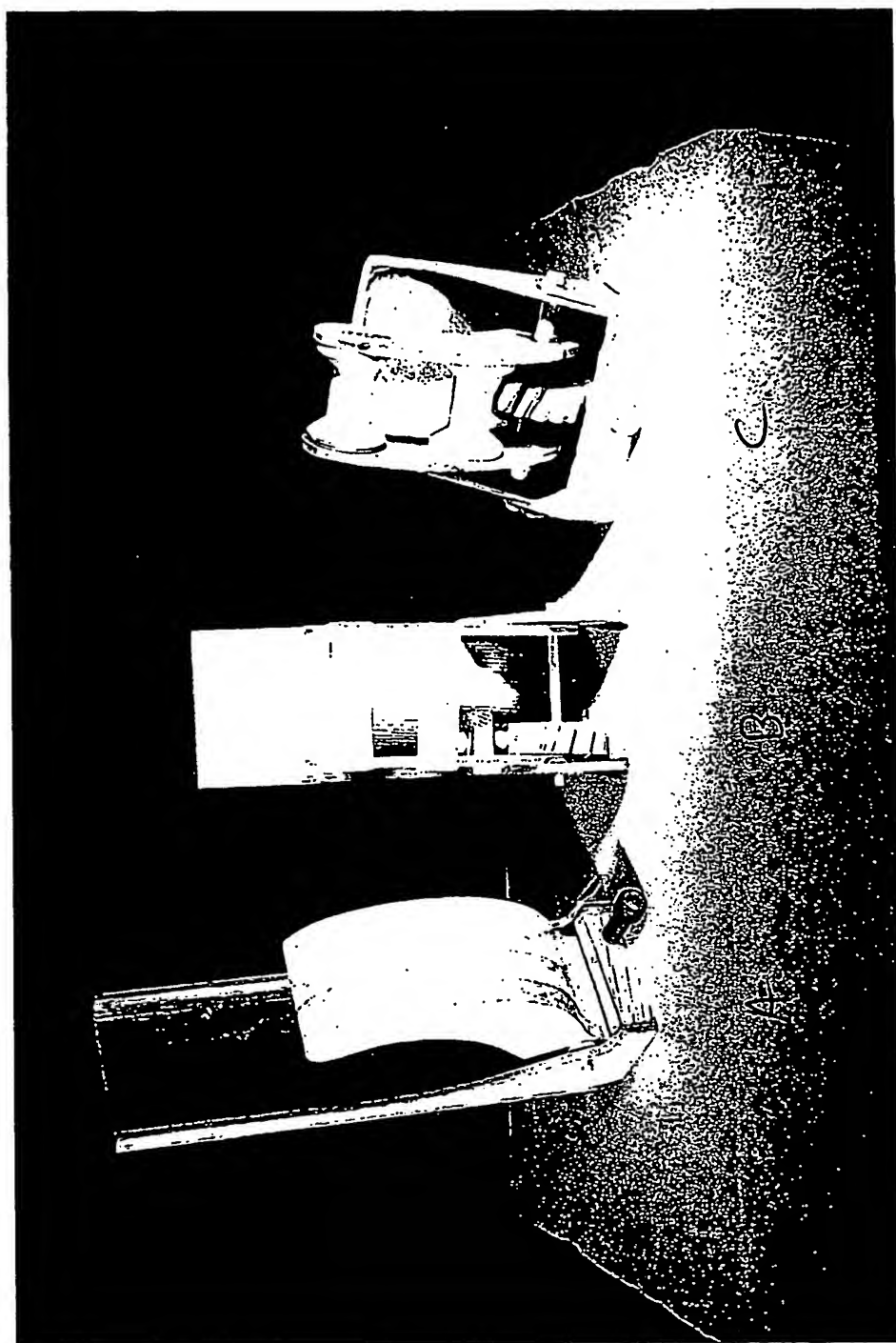
Figure 11

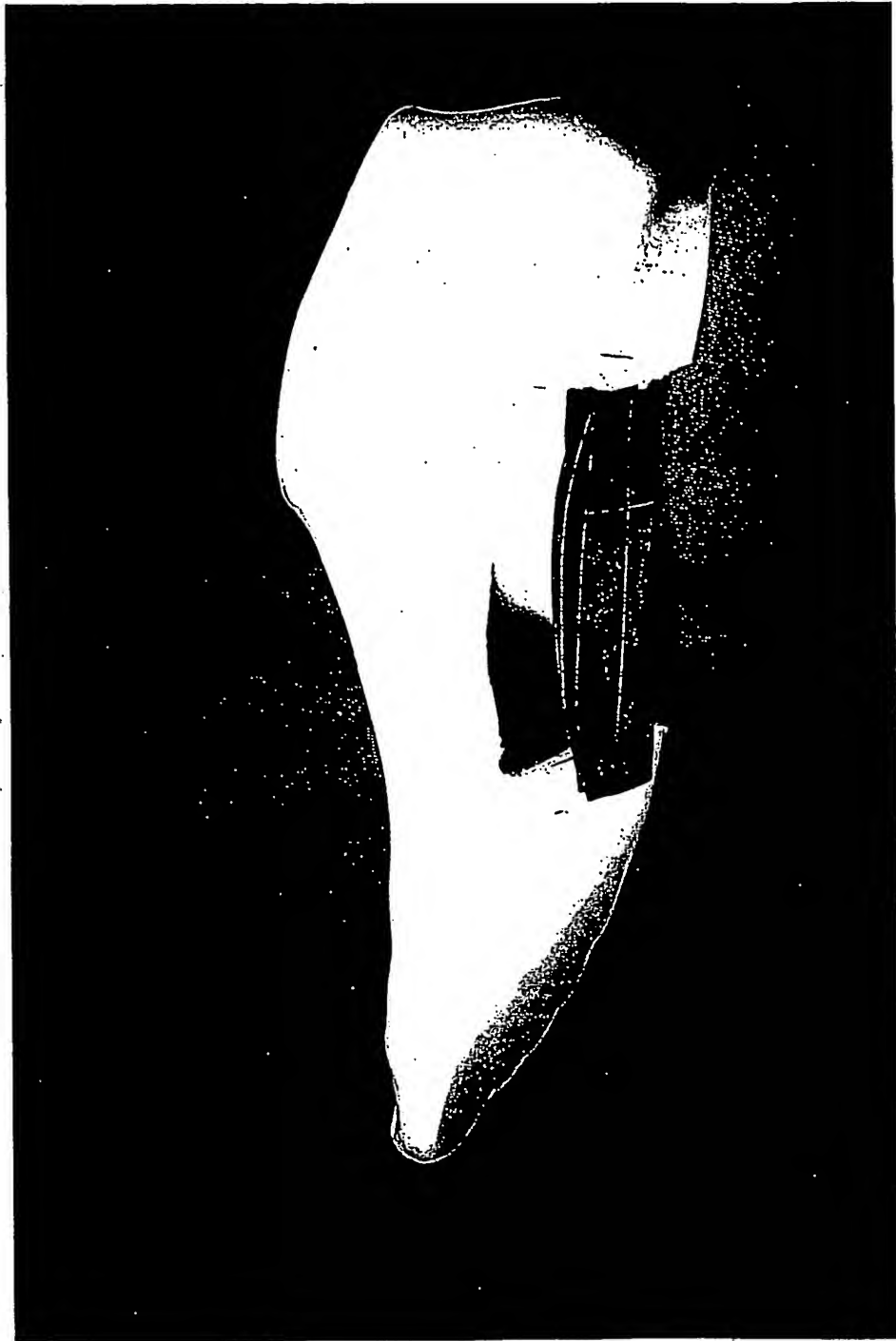


F16 12



Page 13



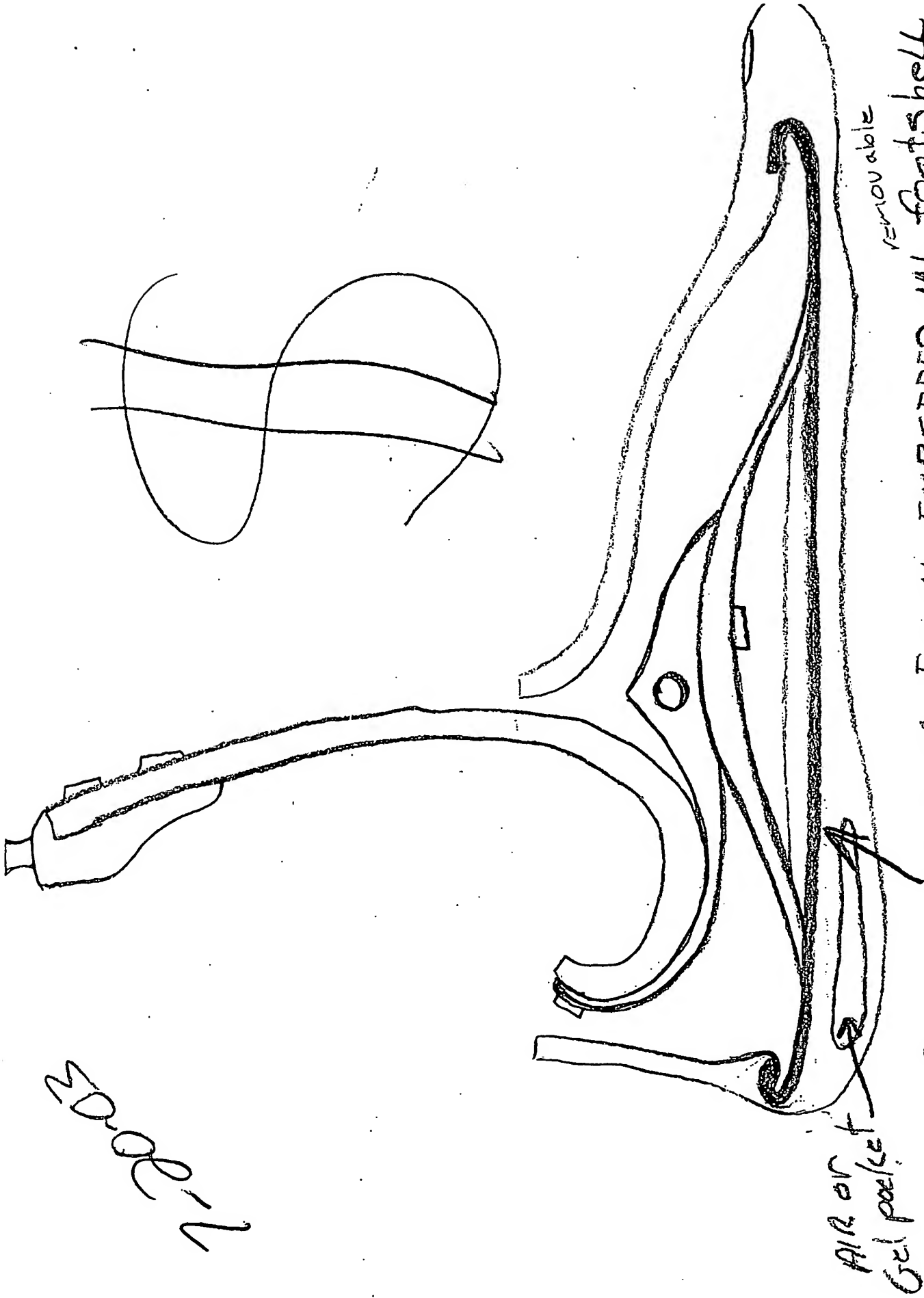


F-10 15



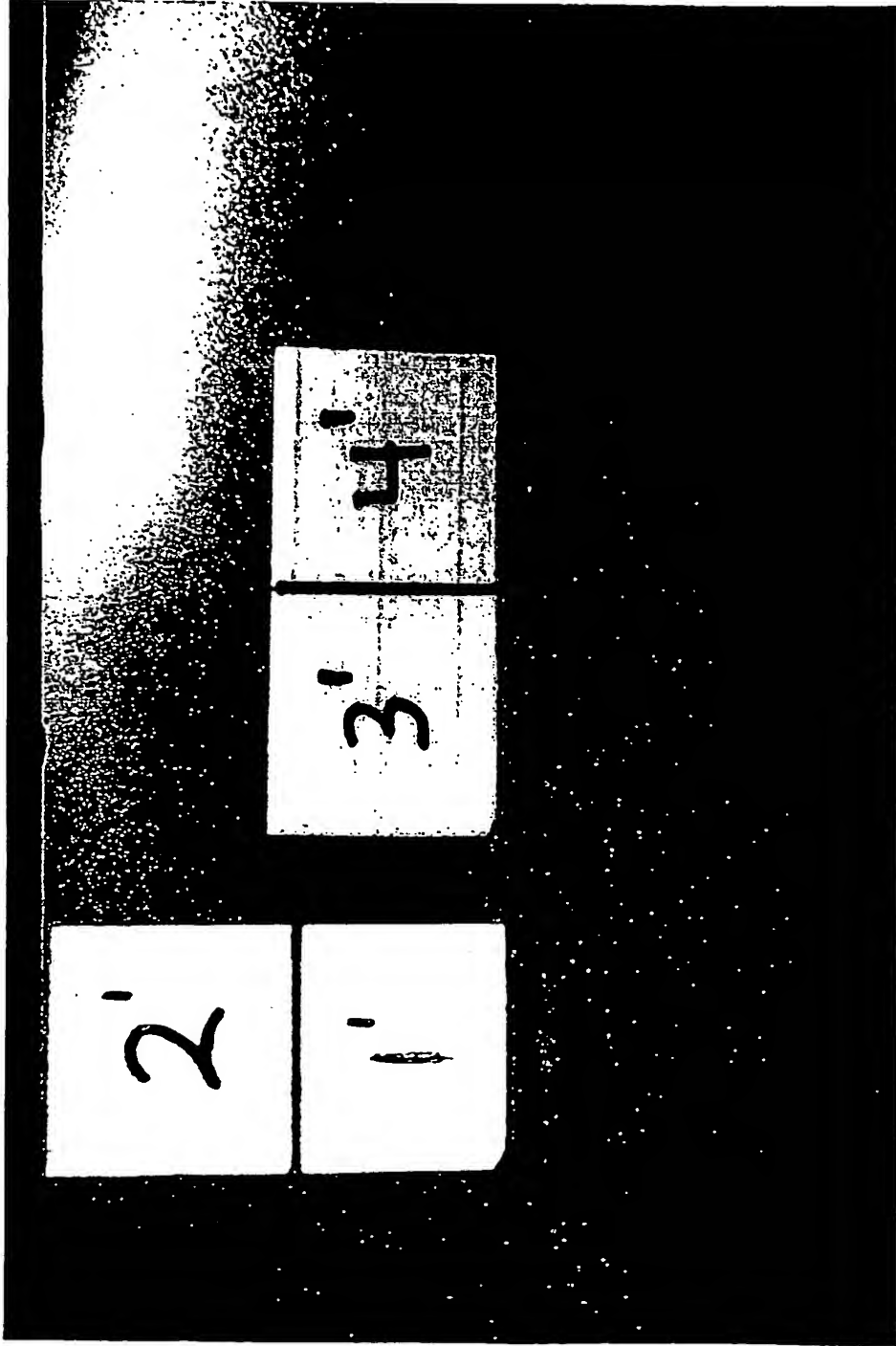
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Good

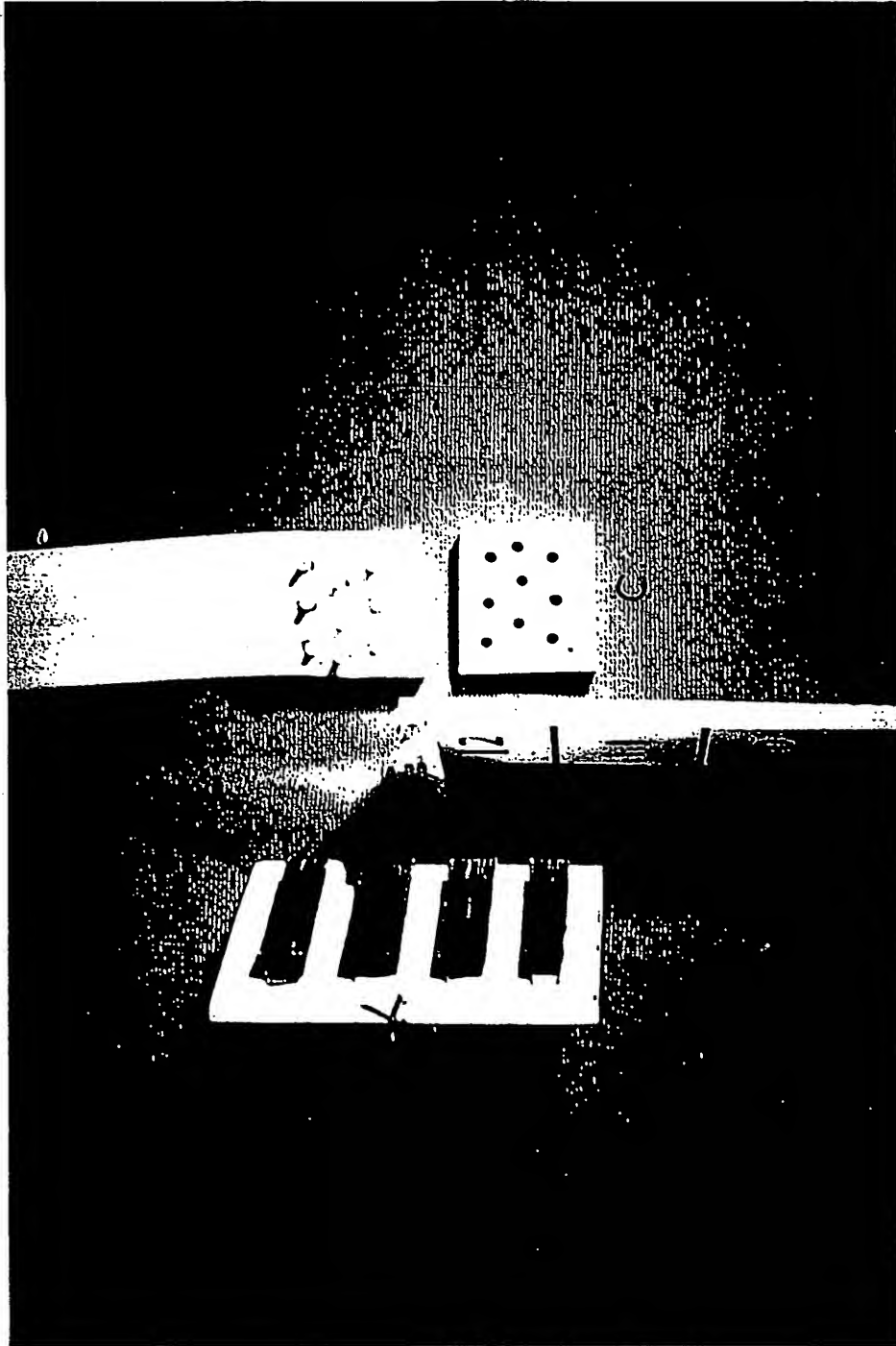


ELASTIC STRAP OR EQUAL EMBEDDED IN footshell
TO ADD IN DYNAMIC RETURN OF foot KEEL





1-10 14



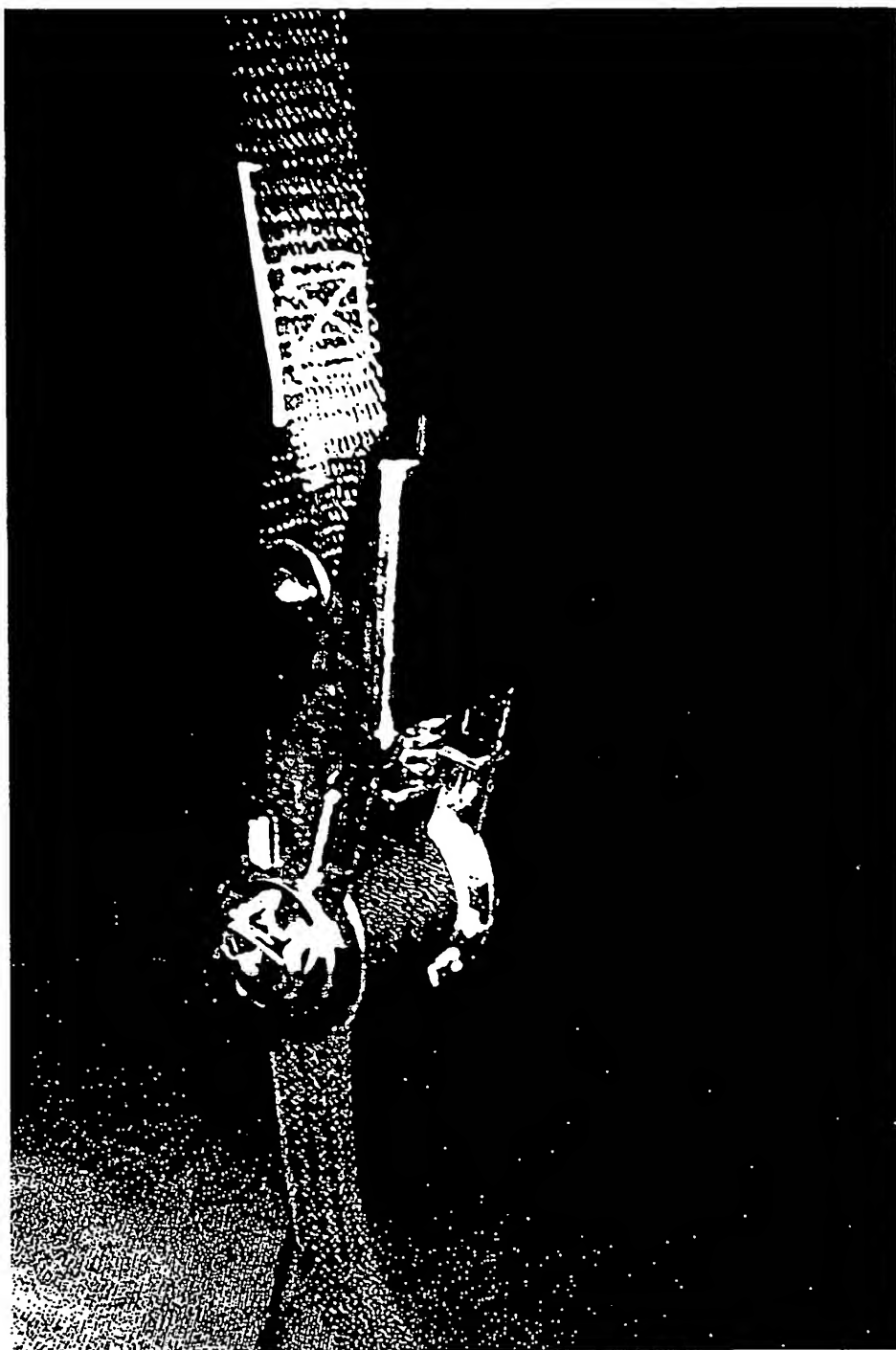


Figure 21

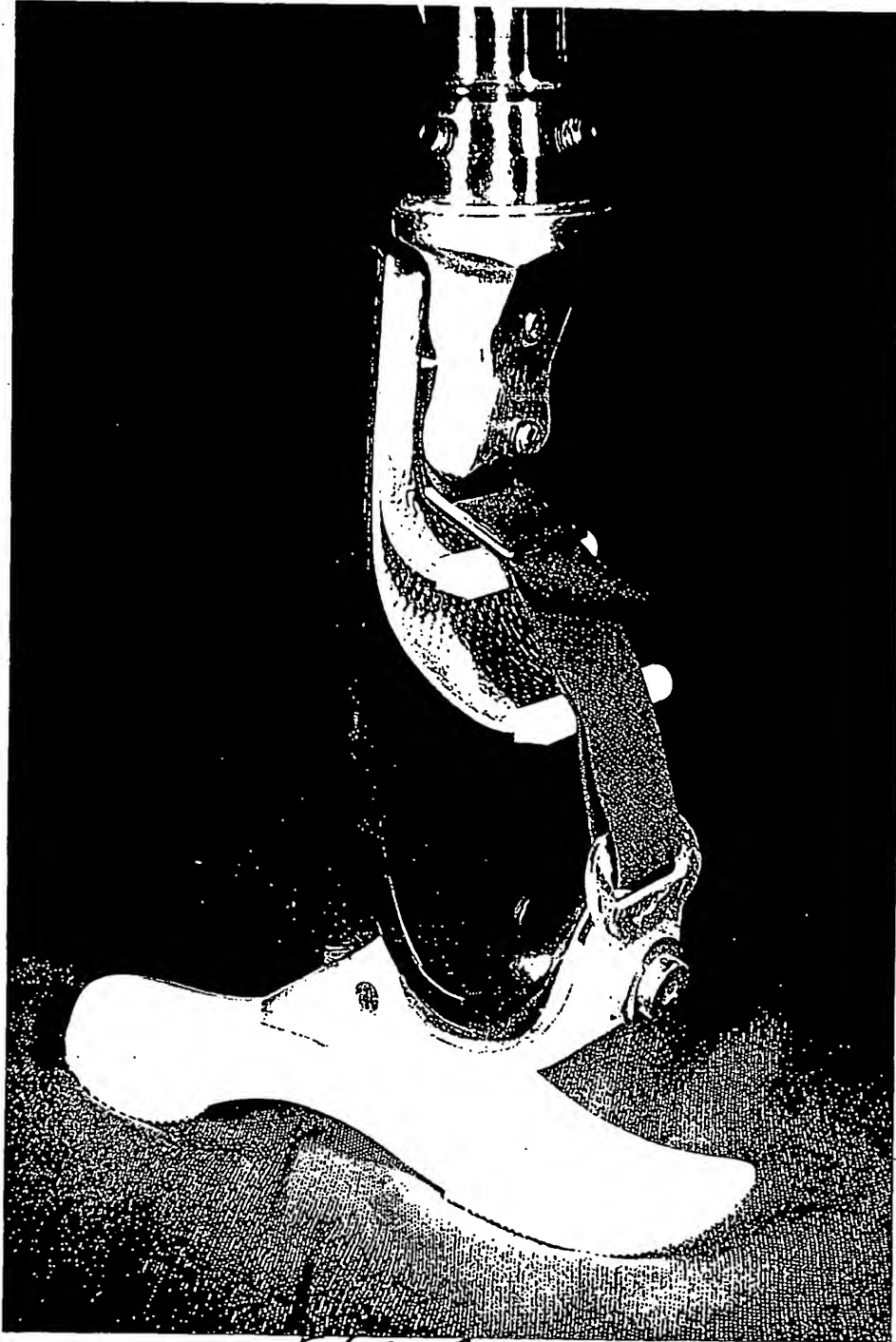
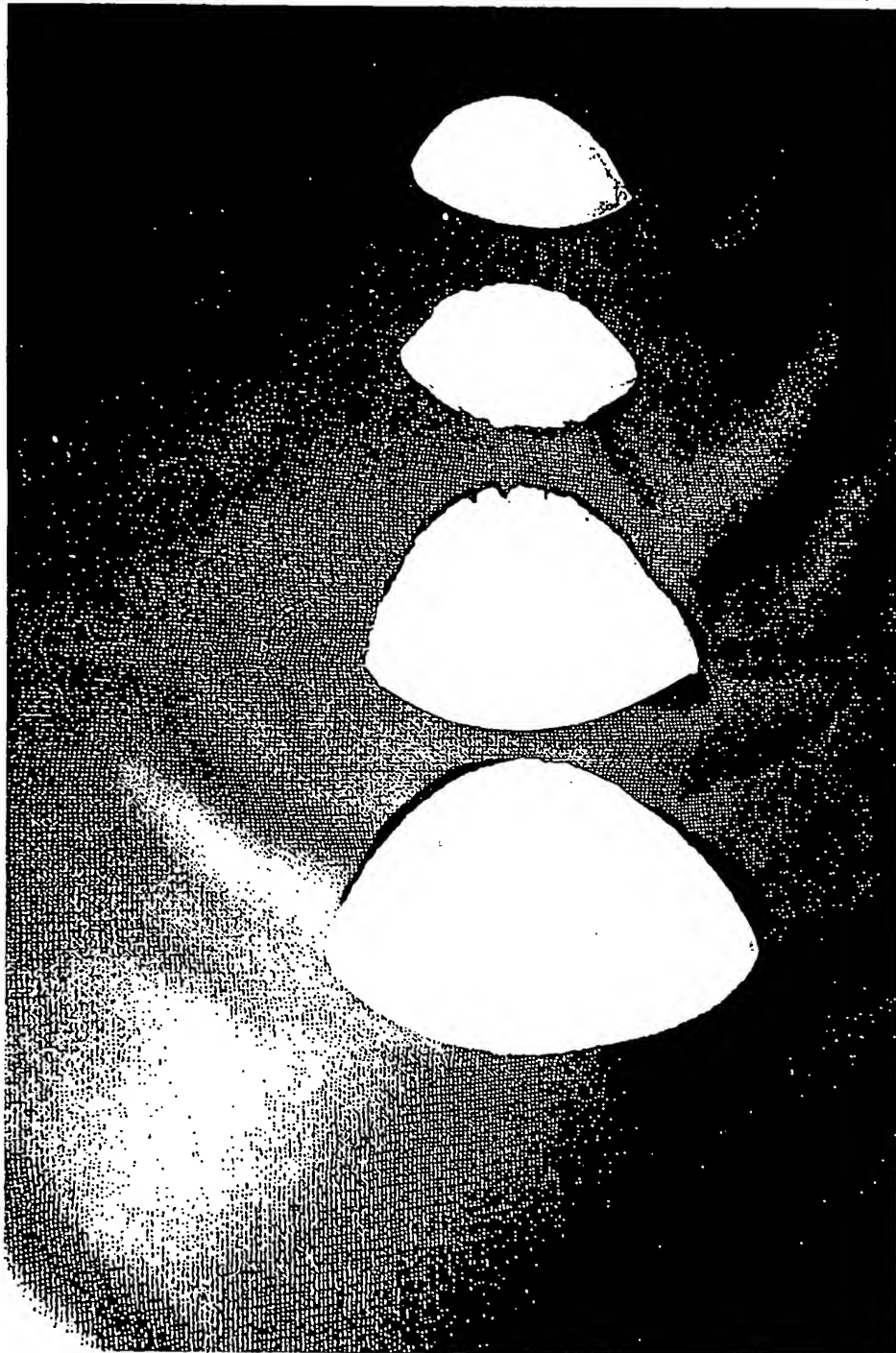
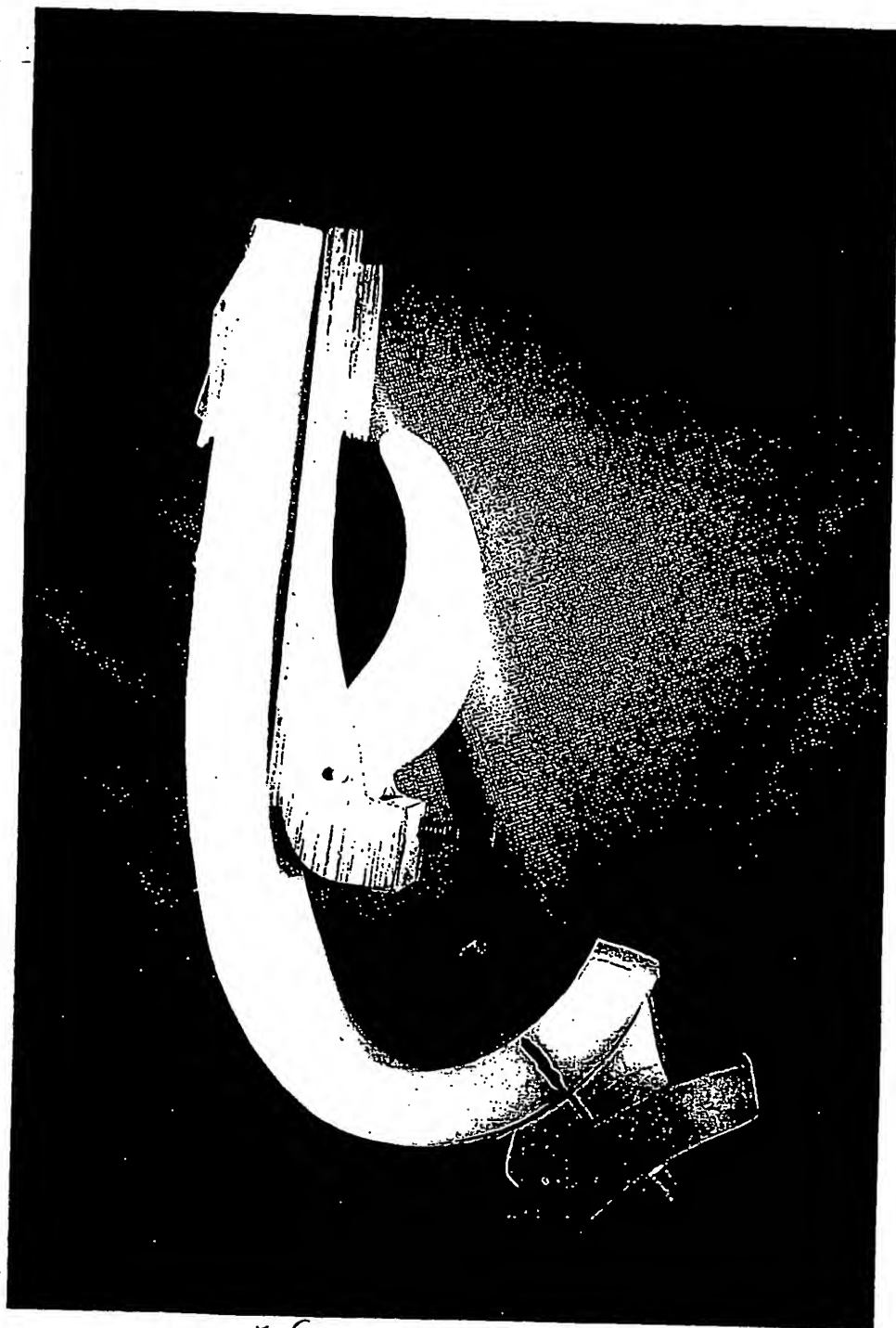


Fig 21 A





F16 23

Pneumatic or Hydraulic-ELECTRIC

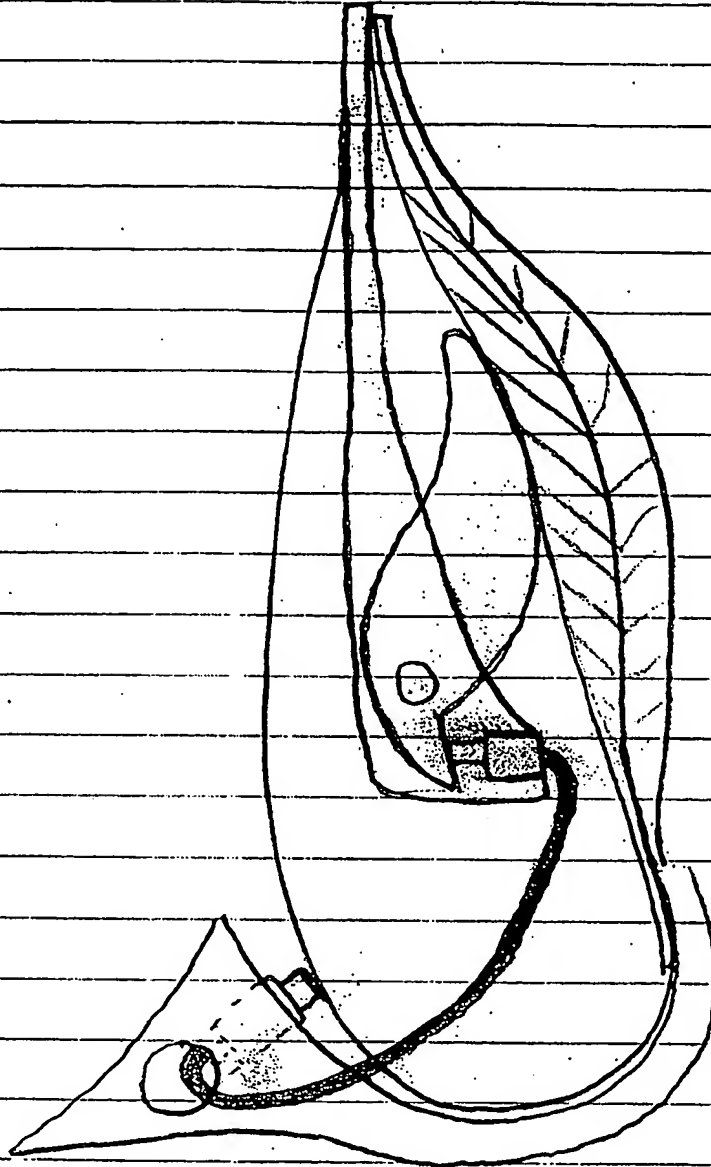


FIGURE 24

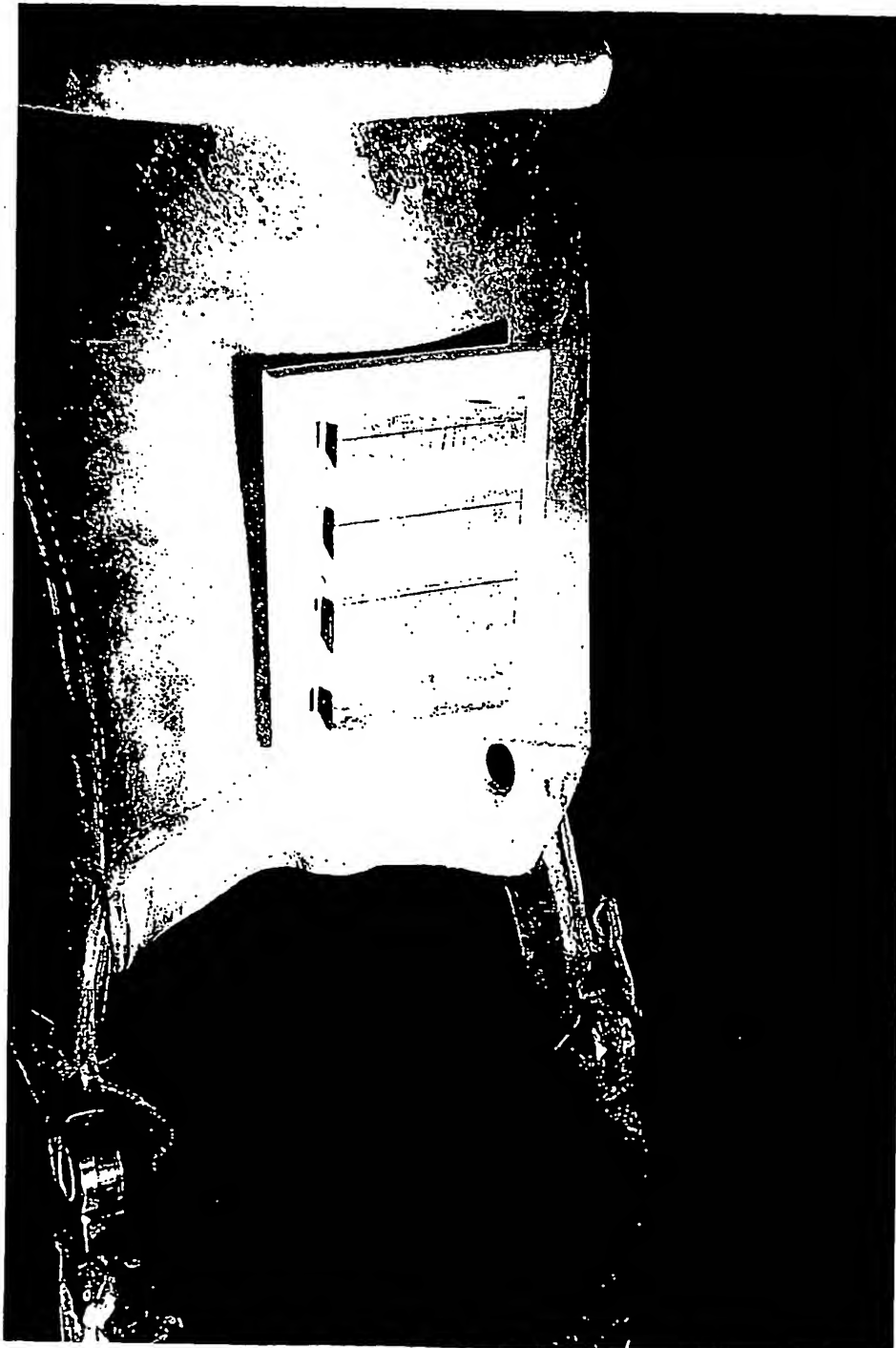


Figure 25



P16enc 26

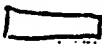





P1627.






4-16-20


OUR PROSTHETIC MUSCLE CAN BE
SHAPED CROSSSECTIONALLY AS A -

 RECTANGULAR,  SQUARE
 , OBLONG, - PLAT,  , 

 ROUND,  TRIANGULAR, QUADRANGULAR

OCT, PENT, ETC.  =  +

TUBULAR  IF THE ABOVE SHAPES TO
 FIGURE A

FOR EXAMPLE  .

THE ELONGATED SHAPES

CAN BE

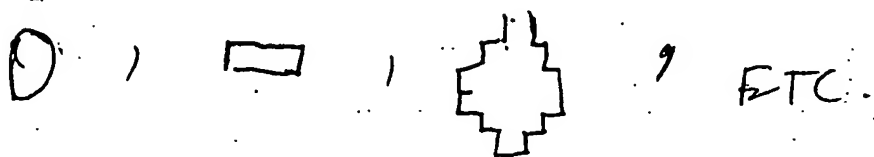
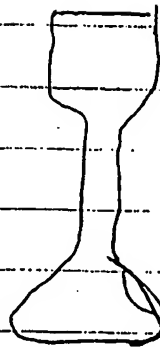


FIGURE B

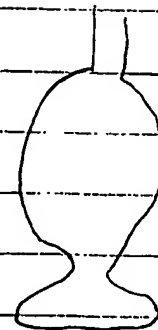
TAB
#2



m



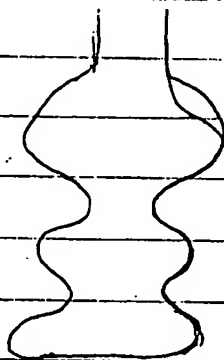
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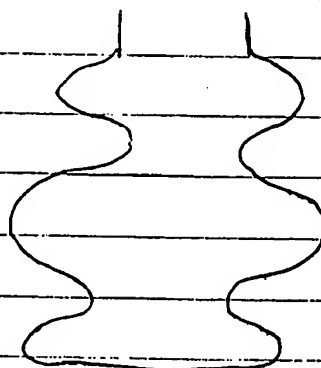
o

(22)

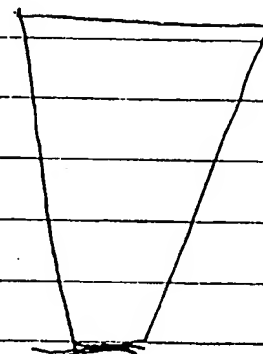
IN CUTOUTS CHANGE FOR A SINGLE LEAF SPRING
EITHER SINGLE + OR MULTISHAPED. WITH EACH
CONFIGURATION CREATING DIFFERENT SPRING RATES
OF CUTOUTS



p



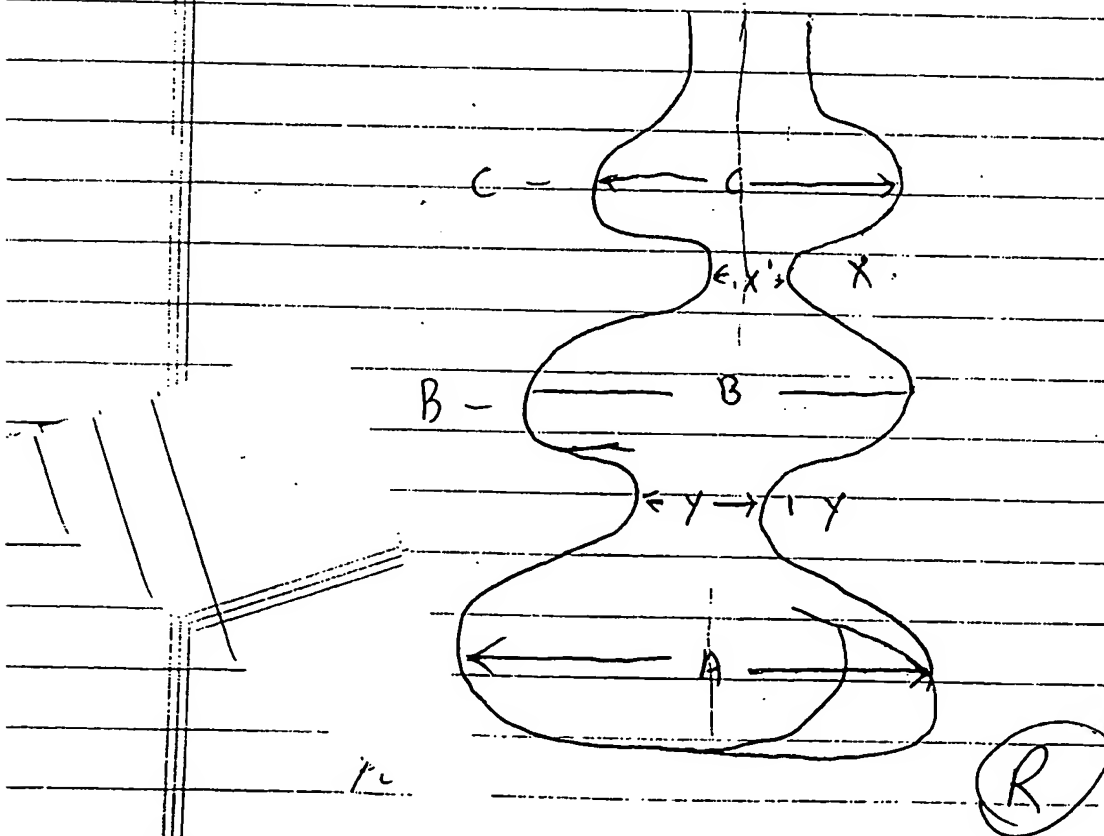
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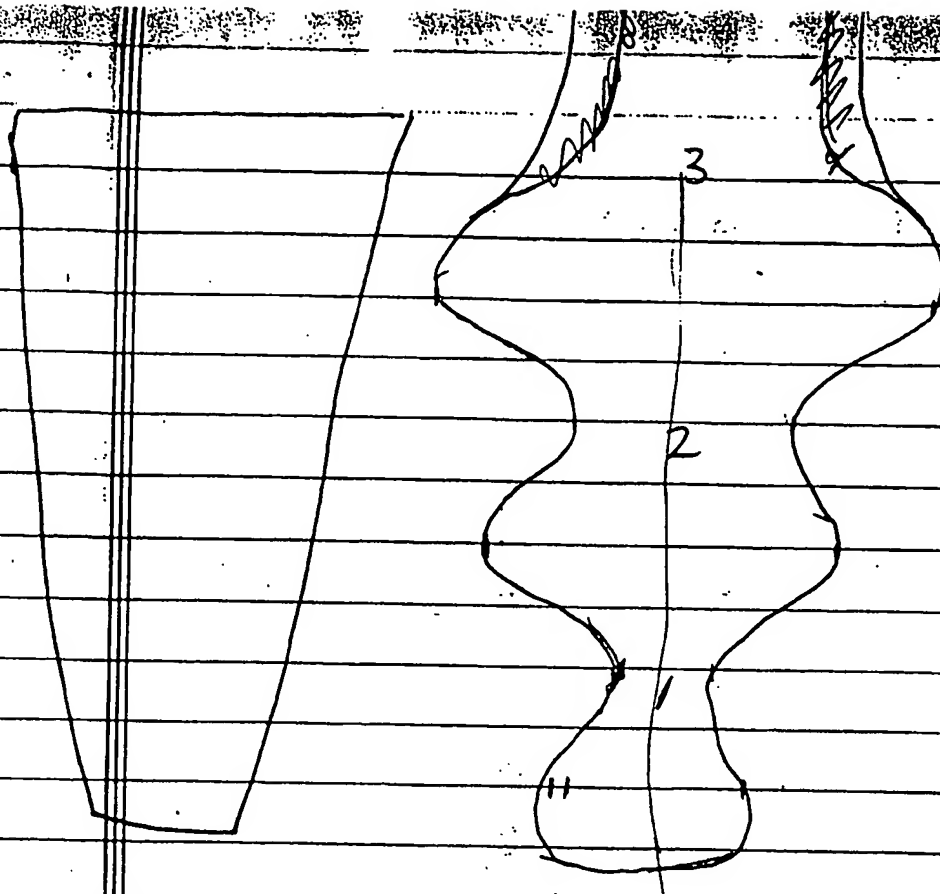


q0

OUR LEAF SPRINGS CHANGE HAVE CONSIDERING
SHAPED SIDES + OR STRAIGHT SIDES

OUR LEAFSPRINGS CAN HAVE SYMMETRY
 + OR ASYMMETRICAL FORM. OUR LEAFSPRING
 CAN HAVE VARIOUS SPRING RATES WITHIN
 THE MONOLITHIC ~~PERIOD~~ PERIOD, WHEREIN
 THE SPRING RATE CAN BE SOFTER ^{OR} FIRMER
 DEPENDENT ON THE CURVILINEAR FORMS.
 FOR EXAMPLE





R16 §

~~WOTD~~ WOULD BE UTILIZED GIVEN US

A MECHANICAL STRUCTURE THAT

RAMP UP ITS SPRING RATE ~~TO~~
PROPORTIONAL TO ITS FORCE LOAD.
~~AS DETERMINED BY ITS LOAD.~~

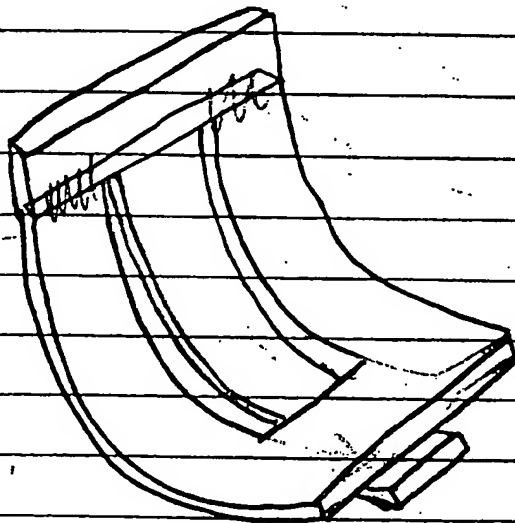
ANOTHER ~~FEED~~ VARIED EMBROIDMENT

WOULD BE TO HAVE A LEAF SPRING

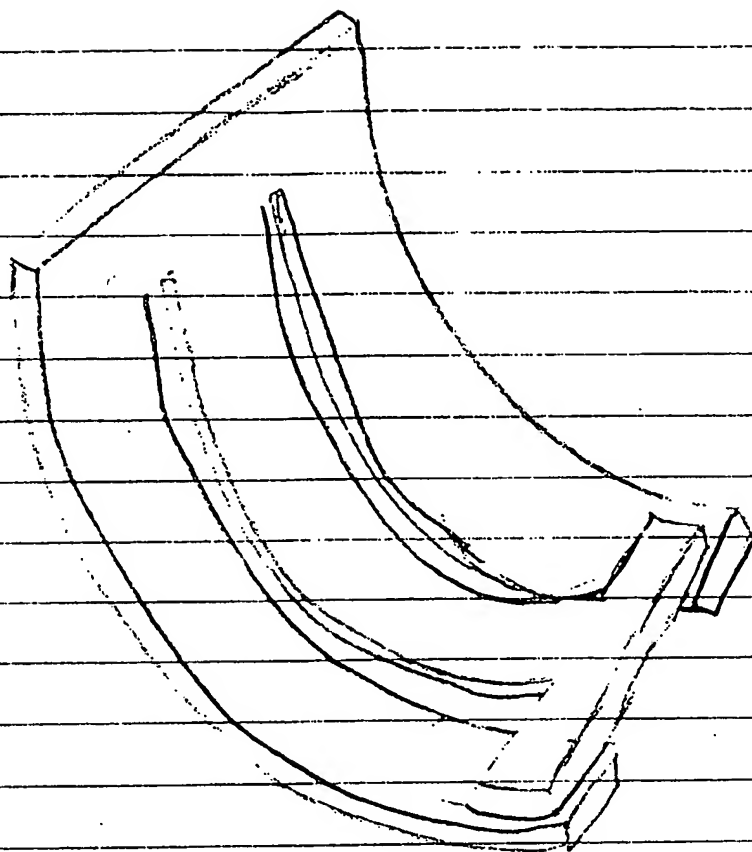
THAT HAS A RAISED MIDDLE SECTION

THAT WOULD ~~BE~~ ENGAGE AS FORCE

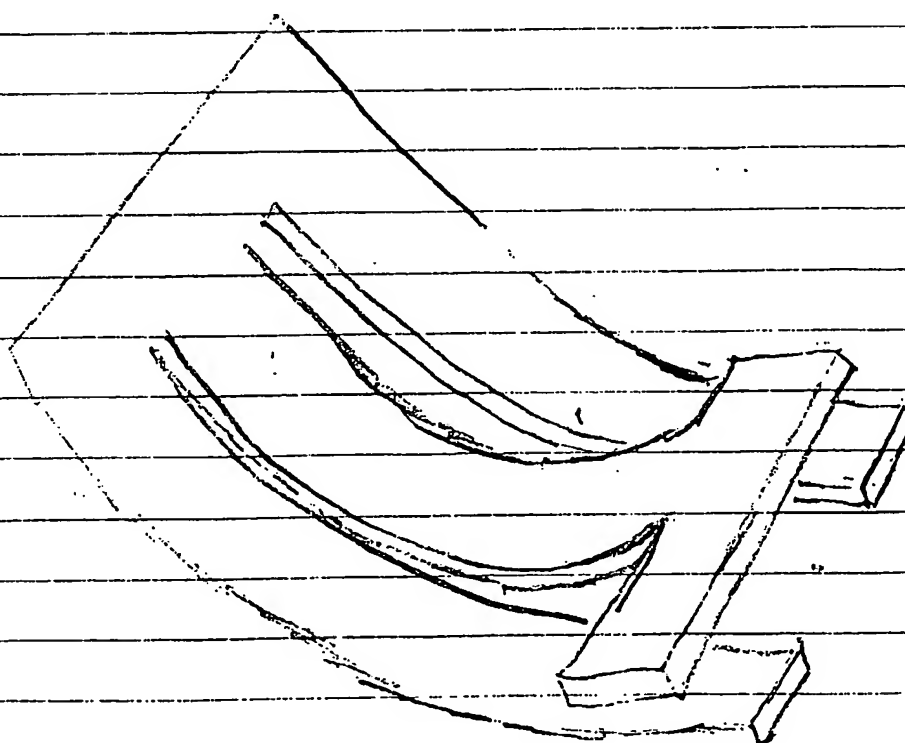
LOADING GOES UP. FOR EXAMPLE T1-4



T1

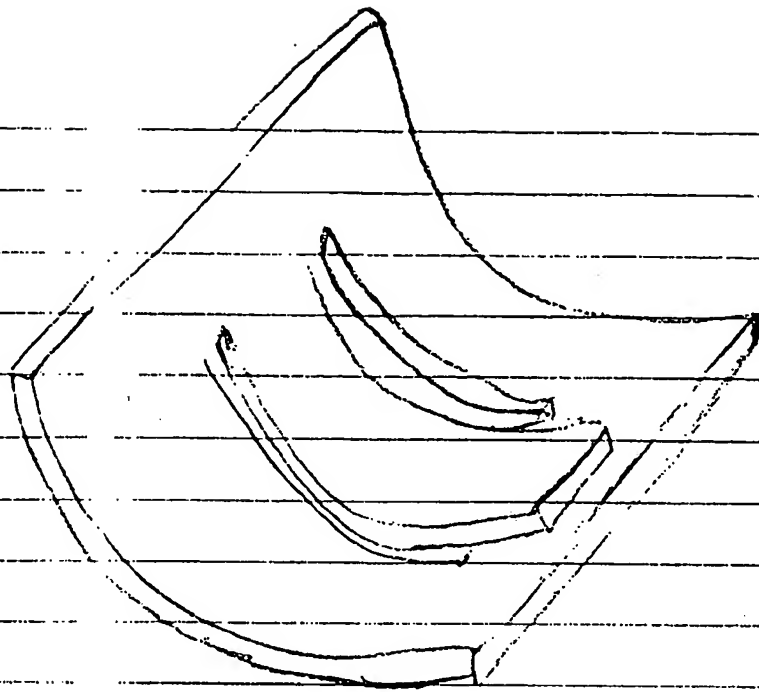


T₂



T₃

235



T4

THIS PARTICULAR CRAFTSMAN DESIGN DOES NOT HAVE TO BE RECTILINEAR RECTILINEAR IN FORM BUT COULD BE CURVILINEAR IN FORM COMBINING BOTH CURVILINEAR + OR RECTILINEAR ~~RECT~~ RECTILINEAR FORMS. ANY BODY SKILLED IN THE ART WOULD KNOW THAT OUR BASIC DESIGN PRINCIPLES COULD BE COMBINED

